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THE PLACE OF RADIATION IN THE TREATMENT OF CEREBELLAR MEDULLOBLASTOMATA

REPORT OF TWENTY CASES*

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INTRODUCTION

NO FRAGMENT of clinical study could better depict the progress of modern medicine than the recent knowledge acquired concerning the group of brain tumors known as gliomata. Fifteen years ago they were largely undifferentiated neoplasms and no adequate therapy or accurate prognosis had been developed. The term *medulloblastoma* was not in use. The separation of the gliomata by Bailey and Cushing[2] into cell types based upon their embryonic derivation was and still is the greatest stimulus to an intelligent appreciation of these tumors. This study by Bailey and Cushing gives all of us the opportunity to offer a justifiable prognosis and a rational method of therapy, based upon a histological study of the tumor cells, and modified by its location and its behavioristic pattern. We can go even further and often accurately prophesy in advance of operation as to what cell-type will predominate in the tumor. This present paper will be limited to a consideration of one subgroup of gliomata, the *cerebellar medulloblastoma*, and we shall consider chiefly the effect of radiotherapy upon the clinical course and the histological structure of these tumors.

HISTORICAL

Fifteen years ago radiotherapy of brain tumors was in a rather unintelligent hit-or-miss form. Numerous cases had been subjected to roentgen therapy, but this had been directed equally at the radiosensitive and the radioresistant tumors. It was impossible to draw logical conclusions from the results; in fact, erroneous assumptions seemed to dominate the field. For example, if a comparatively benign tumor was explored and partly removed and then subjected to radiotherapy, the long survival period was often falsely attributed to the irradiation. Or, similarly, if a malignant type of glioma was found and subsequently irradiated, the rapid recurrence and sometimes the fatal accident of hemorrhage into the tumor was just as falsely blamed on the radiation therapy. A more specific and more accurate demonstration of the wide variation in the natural life history of the different types of gliomata and their wide variation in radiosensitivity can be obtained by comparing the cystic astrocytomata of the cerebellum and the cerebellar medulloblastomata. Both occur most frequently in children, often giving identical symptoms and signs, but the prodromal period in the astrocytoma may be consid-

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erably longer than in the medulloblastoma. In the latter the symptoms are rarely of more than six months' duration and frequently are much less. After operation, however, the patient with astrocytoma may reasonably expect a period of freedom from symptoms of five to ten years, and if the operation has been "radical" (i.e., with removal of the mural tumor nodule) he may reasonably expect a permanent cure, whether or not postoperative radiotherapy has been given. The story with medulloblastoma is quite different. No matter how complete and radical the operation has been, there will almost invariably be a recurrence of the signs and symptoms, and of course of the tumor, in three to six months, unless radiotherapy is given subsequent to the operation. Obviously, if these two tumors were simply classified as "cerebellar gliomata" the greatest discrepancies would be found both in surgical end-results and in the results following postoperative radiotherapy. Thus it would seem that at least a biopsy of the tumor should always be obtained before initiating radiotherapy. Later we shall offer evidence which appears to indicate that the response of these tumors to the test of irradiation is characteristic and can be used in place of a histological verification.

PATHOLOGY AND HISTOLOGY

The cerebellar medulloblastomata are in the great majority of cases, particularly in children, situated in the midline.[1] (The few cases found in adults are more likely to be laterally situated in the cerebellar hemispheres.) This tumor is three times as frequent in males as in females. It is usually soft in texture, very vascular, and invasive. Its usual situation is between the cerebellar hemispheres, underneath the uvula and vermis, lying directly in the fourth ventricle. Quite frequently a smooth prolongation is found extending into and blocking the dilated aqueduct of Sylvius. Though the tumor often appears well defined grossly, as a rule it invades the cerebellar tonsils, vermis, and roof of the fourth ventricle. By its location and frequent involvement of the fourth ventricle and aqueduct, the usual symptoms of onset are almost always those of increased pressure from the internal hydrocephalus, i.e., headache, and vomiting without nausea followed shortly by unsteadiness in walking, and later by the usual cerebellar signs, which will be taken up subsequently.

Histologically these tumors are very cellular, with little or no stroma, and relatively vascular. The cells are small and round or slightly oval, with scanty cytoplasm. The nuclei are rich in chromatin, centrally situated, with one or more nucleoli. Usually there is no architectural arrangement, but occasionally one finds the formation of pseudo-rosettes. There are often a few spongioblasts and less commonly neuroblasts in the sections. Mitotic figures are frequent, but vary in number with the different tumors. The tumors in this series were graded histologically as to the degree of malignancy, based upon their cellularity, their vascularity, the amount of stroma, the number of mitoses, and the degree of differentiation of the cells. There was no correlation between any of these factors and the duration of life, nor could the apparent radiosensitivity be prophesied from the histological picture. The most malignant tumor histologically was found in Case XII in whom there was a recurrence of the tumor three months after radical electrosurgical removal, but the patient survived thirty-five months. However, the prognosis and the actual period of survival depend upon many other factors in addition to the histological structure. All other factors would have to be equal in order to justify dependence upon the above negative studies. The only striking finding was that the three most vascular tumors came from patients who survived for an average of forty-five months. This could be only a coincidence. The cells usually invade the neighboring brain by direct infiltration, and also are readily transplanted along the cerebrospinal pathways. Transplantation may extend forward through the aqueduct

to the third ventricle, or even into the lateral ventricles, but usually the cells are seeded "by gravity" down the spinal cord. In this latter location they are usually subarachnoid in position, though occasionally they do invade both the dura and the spinal cord (Fig. 5). Symptoms arise from these metastases through local pressure or because the cerebrospinal fluid pathway is blocked. Occasionally these tumors extend out along the spinal nerve roots, presumably accounting for the excruciating pain in the pelvis and lower extremities sometimes found late in the disease.[4] In only one case have we been able to demonstrate invasion of the overlying cranial bone. They do not "metastasize" outside of the central nervous system.

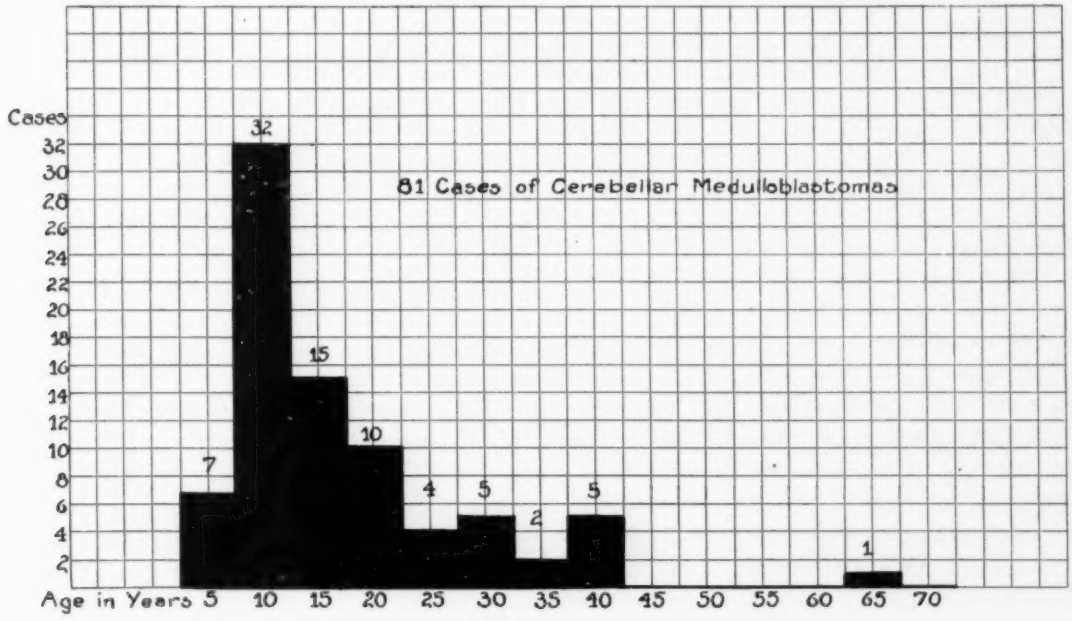


FIG. 1. The age incidence in semi-decades of 81 cases of cerebellar medulloblastoma.

The age and sex incidence is striking, as Cushing pointed out in his monograph on these tumors.[12] The great majority of them occur before adolescence, the peak being in the five to ten year period (Fig. 1), and they are three times as frequent in male children as in female children. They are relatively infrequent, however, forming less than 1 per cent of all intracranial tumors, and only 8.4 per cent of the 862 cases of verified gliomata in Cushing's series.[10]

CLINICAL COURSE

The clinical picture has already been suggested. Perhaps no better way to delineate the striking onset, development, and course of the disease could be found than to quote Cushing's "composite case."[12]

A preadolescent child previously in good health begins to complain of headaches or of suboccipital discomfort and to have occasional attacks of vomiting without preliminary nausea, usually on first arising in the morning. Attendance at school meanwhile may continue, but the teacher soon notices that the child is listless or inattentive and the character of its work noticeably falls off. Ere long it is apparent that there is some unwonted clumsiness of movement and awkwardness in gait. The mother may find that the child quickly outgrows its caps and she thinks the head enlarges unduly fast. In the course of time it is noticed, at home or at school, that the child's sight is impaired; or a beginning squint of one eye may be detected, even in the absence of any complaint of double vision. The family doctor, who has previously suspected some gastro-intestinal disorder, may then have the eyegrounds

examined, and to the surprise of everyone a choked disc is found. Three or four months on the average have elapsed, and at about this stage of the malady many cases first come under hospital care.

Should the condition not be recognized so soon, the symptoms relentlessly progress. The clumsiness increases until the gait gradually becomes so ataxic that walking without support is difficult; vomiting grows more frequent, the child begins to lose weight; the muscles become wasted and atonic; there may be a slight facial palsy; the internal squint may become bilateral and finally "fainting spells" occur, characterized by extensor rigidities that may be precipitated by slight changes in position. Ere this the child will have become bedridden. The whole story, if uninterrupted by operation, may cover a period averaging from eight to nine months.

As noted previously, the outstanding triad of symptoms is headache, vomiting without nausea, and unsteadiness in walking. The headache is not usually severe and is intermittent, most frequent on arising in the morning. It may be more of a discomfort or a feeling of pressure than a real pain, and is often associated with slight stiffness of the neck. Extension of the neck is usually more uncomfortable than flexion, in contrast with meningitis.

Vomiting occurs particularly on arising in the morning and is not preceded by nausea. It may be forceful or explosive in character, the true cerebral vomiting, and does not interfere with the patient's welfare in the early stages. As a rule, the child will eat the usual breakfast soon afterward and then go about the day's work or play until some of the other sequelae appear, commonly, unsteadiness in walking, failure of vision or double vision (abducens palsy), loss of weight, enlargement of the head (hydrocephalus) and convulsions.

In the adult cases, where the tumor is more frequently laterally situated, the order of events is changed; the pressure syndrome with vomiting may be a minor feature, and the symptoms are more suggestive of the cerebello-pontine angle tumor, such as tinnitus, deafness, Ménière's syndrome, etc.[9] In addition there is ataxia and other "cerebellar" signs.

PROGNOSIS

As suggested above, the course of the tumor is rapidly downhill, and if not interrupted by operation or radiotherapy will eventuate fatally in about twelve months. Operation alone, no matter how careful or radical, will rarely give relief of symptoms for more than six months. If radiotherapy is added to operation then the survival period is considerably lengthened, as will be noted in the following tables. In the entire series of 81 cases, however, only 3 have survived for five years or more, and only one of these is apparently free of the disease at present. Is it any wonder, therefore, that we seek a better method of therapy than we have had in the past? Is it not logical to suggest, since operation alone has failed to cure a single one of these patients, and since operation plus postoperative radiotherapy has failed in all but one patient, though it considerably prolonged many of their lives, that we try radiotherapy alone in a series of cases, avoiding even an exploratory operation and biopsy because of the dangers of inoculating the meninges and the cerebrospinal fluid pathways? We are not the first to suggest such a course, as Cushing[12] notes 2 patients in his 1930 monograph who were given radiotherapy to the cerebellar area on the suspicion that they might have this type of radiosensitive tumor, even though one of them had a negative cerebellar exploration.

RADIOTHERAPY

Béclère[5,6] first proposed radiotherapy of intracranial neoplasms without even a decompression. Let us consider, therefore, what the advantages of such a course may be, as well as the disadvantages and dangers. In the first place, there would be a decided drop in immediate mortality, for these cerebellar medulloblastomata are probably the most unsatisfactory of all intracranial neoplasms from a surgical

standpoint, with a postoperative mortality of about 25 per cent. In the series of 54 cases receiving radiotherapy, there was only one death attributable to radiation reaction and 2 cases of coma following irradiation, a case mortality of less than 2 per cent. We believe the reaction can be minimized or avoided completely, as will be outlined later, so that there should be no mortality from radiotherapy unless the patient is first seen *in extremis* when any form of therapy may be followed by a fatality (cf. Case xx). In the second place, any operation on the brain is difficult, time-consuming, and expensive. This method of irradiation would avoid the expense of such a highly technical procedure, would conserve the time of the surgeon, of his assistants, and of the operating room staff, would make them available for more favorable cases and would save money both for the patient and the hospital.

Furthermore, the centers where good intracranial surgery is being done are still all too few and far between, certainly less than a tenth of the number of places where competent radiotherapy is being given. In other words, good radiotherapy is far more easily and widely available than correspondingly good intracranial surgery.

Finally, we believe that our limited experience shows that the results are just as good with radiotherapy alone as when given following operation, but more time and a longer series of cases will be necessary to settle this point.

What are the disadvantages and dangers? Béclère[6] stated that the dangers are either immediate or delayed. The immediate danger was from radiation edema, and the delayed or latent one from radiation gliosis. There is, indeed, definite danger from post-irradiation edema, which may come on within a few hours after treatment. This is due to the combination of a very sensitive tumor and a very dangerous position. Reactions such as headache, nausea, and vomiting were common in our earlier cases, and 2 patients went into coma following treatments, but those were the days when "massive doses" were thought to be the ideal method of delivering radiotherapy. For that reason one of us, in an earlier paper[3] strongly advocated at least a decompression. That these reactions can be avoided has been proved by our more recent experience, in which two factors are important: (1) the divided dose technique in which small daily doses are given, and (2) the preparation of the patient by dehydration, which produces the effect of a decompression. Details will be given later.

Technique. The delayed or latent danger of gliosis is apparently quite unimportant. In some of our heavily treated cases Bailey[4] found only slight superficial gliosis in the spinal cord, except where it was overlaid by tumor nodules, where the gliosis was in some instances marked. We believe this to be due to the tumor and its stroma, as is shown in other autopsied cases, for in the areas where no tumor was present, there was no gliosis and yet those areas received the same radiation. Normal nervous tissue is notoriously resistant to radiotherapy, both in man and in the experimental animal.

The most valid objection to this method of radiotherapy without operation, and a logical one, is that if the patient survives we can never prove that he actually harbored the tumor in question. However unscientific this may be, if our method of therapy be successful or even more efficient than our previous methods, and if we can give clinical relief to at least a small number of these suffering children, then we shall accept the epithet of "unscientific" or "unconfirmed" work and do it willingly. For after all, there is nothing further to be gained by simply adding to the number of histologically verified cerebellar gliomas, but the satisfaction of knowing more certainly with what type of tumor one is dealing. Furthermore, if our deductions from our past experiences are correct, the characteristic reaction of these cerebellar medulloblastomata will confirm the diagnosis almost as surely as will a biopsy.

This leads us to the almost inevitable

criticism of such a course as we advocate, namely, that one is not sure what type of tumor is under treatment, and therefore may either do harm by treating a resistant tumor, or by wasting time may endanger the patient's eyesight or even his life. This criticism does not hold in actual practice, however, for one can tell by the marked clinical improvement in ten days whether or not the tumor is a medulloblastoma, and can in the meantime avoid any further increase in the intracranial tension by dehydrating the patient. One must not confuse the slight improvement following dehydration commonly seen in any intracranial hypertensive lesion with the almost miraculous change usually seen following irradiation of the medulloblastomata, for these tumors are by far the most sensitive to radiotherapy of all intracranial tumors. They may well be called the lymphomata of the central nervous system as far as their radiosensitivity is concerned, and are just as susceptible to cure by surgery as are the lymphomata.

The other conditions or tumors which may simulate the medulloblastoma in the cerebellum of a child or young adult are, in their order of frequency, astrocytoma, angioma, ependymoma, tuberculoma, adhesive arachnoiditis with internal hydrocephalus, and lead poisoning. The acoustic neurinomata occur almost exclusively in adults, have a strikingly characteristic chronological symptomatology, and are not radiosensitive, so that what is said below about the astrocytomata will apply as well to them.

The astrocytomata are slowly growing, fairly benign gliomata, usually cystic, are quite favorable for operative removal with a low operative mortality, and are not radiosensitive, in our experience. If by mistake one were irradiated thoroughly, there would be at the worst only a delay of ten days, with no harm done to the patient and no increased hazard or difficulty at subsequent operation. In fact, the ten days' rest and supportive therapy may put the patient in better condition for operation. In many cases that much time or more is frequently spent in persuading the parents that an operation is necessary. If given the alternative of radiotherapy and this is without success the decision is made easier. Again we must warn against accepting the slight improvement due to the decompressive effect of dehydration as a result of radiotherapy. The improvement must be prompt, and it must be marked if it is to fall within our expectations. We treated one case of cystic astrocytoma in our series in the mistaken belief that it might be a medulloblastoma, and the very slight improvement led to surgical intervention two weeks after the first treatment, confirming the diagnosis of astrocytoma. As a rule, the only pre-operative or pre-irradiation means of differentiating these two tumors lies in the fact that the symptoms are of longer duration in the astrocytoma, averaging one to two years, while they are almost always six months or less in the medulloblastoma. The cystic astrocytomata are one and one-half times as frequent in the series of 862 verified gliomata in Cushing's series as the medulloblastomata. There were 91 of the former and 68 of the latter.[10]

The angiomata of the cerebellum are comparatively rare, a total of 25 being reported in Cushing's series.[11] Some of them are favorable for operation, particularly the cystic ones described by Lindau,[18] while others are quite unfavorable. Some of the latter are radiosensitive, but not to the extent of the medulloblastomata. It would certainly do no harm to irradiate a cerebellar angioma to exclude the possibility of a medulloblastoma, and no confusion should arise from the relatively slow response. (For details see Cushing's monograph.[11])

The ependymomata are also less frequent than the medulloblastomata, a total of 19 being found in Cushing's series.[10] They are also radioresistant, and the remarks concerning astrocytomata apply equally well to this type of tumor.

The cerebellar tuberculomata are still

rarer, and in this case it is quite conceivable that harm may be done by irradiating an unknown cerebellar lesion which turns out to be a tuberculoma. There is some slight evidence that intensive irradiation of a tuberculous lesion may tend to spread the disease, but this has been denied by others. However that may be, the prognosis in cerebellar tuberculomata is almost invariably fatal; they are not amenable to radical removal, but do best with only decompression and the usual supportive treatment given as in surgical tuberculosis elsewhere in the body. Tuberculoma may well be suspected if there is evidence of tuberculosis elsewhere in the patient, or if the roentgen examination demonstrates calcified nodules in the cerebellar hemisphere.

Ependymomata may also show considerable calcification, less discrete than the tuberculomata, in our experience. We have not seen calcification in any of the cerebellar medulloblastomata.

The differential diagnosis of chronic arachnoiditis can frequently be made from the history, which usually contains an antecedent or precipitating infection. It may also be differentiated, in our experience, by ventriculograms which will show a widely dilated fourth ventricle with no encroaching tumor shadow. This condition is also amenable to surgery.[13] We have had no experience with the radiotherapy of this condition, but would not expect any immediate benefit or harm from such a procedure.

Lead encephalopathy in children gives signs and symptoms closely simulating those produced by a cerebellar tumor. Bucy and Buchanan[8] in a recent article concluded that there are no positive criteria of lead encephalopathy in children and only constant vigilance and the use, when indicated, of all the diagnostic methods available will serve to establish the correct diagnosis. The presence on roentgenograms of lead lines in the diaphyses of the radii and tibiae is one of the most constant findings.

Let us consider next the methods of radiotherapy and the results obtained in this type of tumor by others, and finally our present method and results. Béclère[6] first proposed irradiation of intracranial neoplasms without a preliminary decompression, and it is common practice in many continental clinics to irradiate a suspected brain tumor and determine its radiosensitivity before resorting to surgery. We do not advocate this blind method of therapy which has many obvious disadvantages and dangers, and which may lead to erroneous conclusions and assumptions, as previously noted. Cushing has aptly remarked that in clinics where the neurosurgery is poorly done, radiotherapy is most often employed and more reliance placed upon it. We believe, however, that there are certain intracranial lesions which may best be handled by means of irradiation, just as there are others in which irradiation is a waste of time, and that in many cases the histological type of tumor may be suggested by a careful history, physical and roentgen examination, and laboratory findings. Béclère did not have the classification of gliomata into subgroups to help him when he wrote his article.

Bailey, Sosman, and Van Dessel,[3] in 1928, reported 12 cases of medulloblastomata in which operation was followed by radiotherapy. The average survival period after operation was thirty-four months. They concluded that irradiation would not effect a cure, but would retard the growth and prolong life. They recommended radiotherapy only after decompression, as did the earlier writer, Towne,[19] and later Heinismann and Czerny.[17]

Tracy and Mandeville[20] reported 3 cases treated surgically, followed by intensive irradiation. All three were alive and well at the time of their report twenty-four, eighteen, and ten months respectively following operation. They contend that decompression should always precede irradiation and that roentgen therapy should be discontinued when the tumor becomes radioresistant, to avoid damage to surrounding normal tissue.

Brody and German[7] in a report of 15 cases include the 3 cases reported by Tracy and Mandeville. These are Cases 6, 8, and 10, respectively. Case 6 died one week following a second operation, giving a survival period of thirty-one months. Cases 8 and 10 were alive and well at the time of the report, giving an average postoperative survival period of thirty-three months for the 3 cases originally reported. Case 8 was operated on a second time with removal of dense fibrous tissue from the tumor area, but no tumor cells were found. Analysis of the remaining 12 cases reported by Brody and German shows that there were 4 postoperative fatalities; 4 died either of progression of the disease or of intercurrent infection; 1 was not followed; 3 had roentgen therapy and were living and well at the time of the report, giving an average survival period for those irradiated of 16.6 months.

Elsberg and Gotten[16] reported 23 cases of cerebellar medulloblastoma with an average survival period of 17.3 months, after discounting a case mortality of 15.8 per cent. They advocated conservatism surgically, with decompression and biopsy followed by intensive roentgen therapy, and showed that the results were as good as those following radical removal of the tumor followed by radiotherapy. They opposed preoperative irradiation without decompression because of the danger of edema and cerebrospinal fluid block. The details of the radiotherapy were not given.

Lereboullet, quoted by Elsberg and Gotten,[16] states that the survival period is usually less than a year without surgery, and rarely more than a year with surgery. The average survival period was longer in the patients who were not operated upon.

In Cushing's[12] series of 61 cases, 40 survived operation for an average of 13.9 months. These are analyzed below in groups with and without radiotherapy, and compared with this present group.

Bailey,[4] in 1930, studied the effect of irradiation on cerebellar medulloblastomata, including in his study many of Cushing's cases treated in our roentgen department. He noted that the tumor-infiltrated leptomeninx was transformed by irradiation into dense fibrous tissue, and that frequently no tumor cells could be identified microscopically. In other areas the cells were rare, their nuclei pyknotic, mitoses were infrequent and abnormal. He also noted that tumor nodules were sometimes transformed into masses of collagen.

The earlier cases in Cushing's series received roentgen therapy only to the cerebellar area, and in few fairly large doses. We soon learned that the tumor could transplant itself down the spinal cord and this led to prophylactic irradiation of the spinal cord at the first postoperative radiotherapeutic session. It was several years later before an autopsy disclosed a similar transplant or extension forward into the third ventricle, and only recently have we found similar extensions in the subarachnoid fluid pathways over the surface of the brain. Our scope of radiotherapy has been successively increased with each finding until now we irradiate the entire cerebrospinal fluid pathway in each patient.

Bailey[4] proposed thorough irradiation of the cerebrospinal axis after operation, but advised against continued irradiation because of his findings of dense fibrous bands constricting the spinal cord, the nerves, and the arteries, and because of intimal thickening in the small arteries.

We believe that this occurs only when there is a considerable deposit of tumor, i.e., that the fibrous tissue and collagen represent the stroma of the tumor, and that irradiation of the cerebrospinal axis should be repeated at intervals to make sure that all of the tumor cells are killed or sterilized. Details will be given later. We also feel that these transplants of tumor cells are often due to the operation and that if the original tumor is not disturbed by surgical means it can be more easily handled by radiotherapy with much less chance of gravity metastases or transplants. It is quite conceivable that if a considerable nodule of tumor were present in the cere-

bellum and fourth ventricle when radiotherapy was begun, it might be necessary or advantageous to remove its shrunken and fibrosed remains after thorough roentgen irradiation, when the danger of transplanting cells would theoretically be diminished. That is a problem for the future to decide.

Bailey also notes that gliosis (a term perhaps employed to frighten radiotherapists) was found in the spinal cord only under the shrunken tumor nodules, and not in the portions equally irradiated but not covered by the tumor. In experimental animals it required excessive doses of radiation to damage normal central nervous tissue, and then the effect was one of small hemorrhages and small areas of necrosis, presumably due to an effect upon the blood vessels rather than a direct effect on the nervous tissue. As much as 1,500 r at the rate of 300 r a day through each of six portals has been given to animals without any demonstrable lesions in six months.

TECHNIQUE

As noted above, our technique has changed with successive increments in knowledge as to the natural life history and pathological manifestations of this particular tumor. It may well be modified considerably in the future. We can only recommend our present system as the best in our experience up to the present time. The most probable criticism of our work would be that we have undertreated these cases at any given time rather than overtreated them.

All of the roentgen treatments in the present series which were given in our department were given with a 200 kv. mechanically rectified machine. A maximum of 185 kv. with 4 ma. of current was used. This was filtered through 0.5 mm. of rolled copper plus 1 mm. aluminum. The target-skin distance was 40 cm. in most of the cases. The output of the machine under these conditions was 10.8 r per minute with an effective wave length of 0.157 Ångström units. Calibration and wave length determinations were made in air with a Duane ionization chamber and according to Duane's technique.[14,15] Later measurements were made with a commercial ionization chamber calibrated by an air ionization chamber. The maximum suberythema dose with these factors was 600 r, measured in air.

Portals were limited by leaded rubber and lead diaphragms, their size varying with the individual case and the area treated. Ordinarily a portal 10×10 cm. in size was used over the cerebellar area, 15×15 cm. over the lateral ventricles, and 12×30 cm. portals for the spine. One portal was used for the cerebellar area, one for each side of the head, one for the cervical and upper thoracic spine and one for the thoracic (lower) and lumbar spine, five portals in all, only the first three resulting in any cross-firing effect. The maximum dose per portal per day was 300 r, and the maximum to any one portal 600 r in any one series. In our later cases without decompression we have given a trial dose of only 200 r to the cerebellum and repeated it daily up to 800 r if there was no reaction. In these same cases the "prophylactic" irradiation to the sides of the head and to the spine can be given at the rate of 300 r per day unless there are clinical evidences of tumor in these areas. Ordinarily it is only the irradiation to the cerebellum which must be given slowly and carefully at first to avoid blocking the aqueduct by edema in the tumor. The precautions outlined earlier in this paper should be kept in mind, particularly the advantages of dehydration as a preliminary decompression factor.

The routine technique at present is to give 200 r per day to the cerebellar area and 300 r to each side of the head covering all portions of the brain and its fluid pathways until a total of 800 r is given to the cerebellum and 600 r to each lateral portal. Then 300 r per day is given to the spine until 600 r has been given to each spinal portal. At the end of six weeks the treatment to the cerebellar area only is re-

peated, and two months later the entire series is repeated. The cerebellar area alone is again treated three months later, then the entire series after three more months, and again after six months. It is quite possible that larger doses at each session, with fewer sessions, may turn out to be preferable.

MATERIAL

There has been no selection of cases in this series other than limitation of our study to those medulloblastomata located in the cerebellum or beneath the tentorium. The diagnosis has been verified in each case by histological study of material obtained either by biopsy or necropsy, except in Case XIV, which has been treated by irradiation only. The cases are presented in chronological order and are subdivided into two groups: A and B. The former includes 13 cases treated by Dr. Cushing, and the latter 7 cases treated by Dr. Cutler. We also have restudied Dr. Cushing's[12] series of cases reported in 1930, with his permission, and present in Table 1 the results of this study (Fig. 2).

ANALYSIS OF RESULTS

An attempt has been made to classify the entire series of medulloblastomata in such a manner as to best explain the clinical effect in terms of prolongation of life due to improved operative and irradiation technique. The entire series of 81 cases has been further subdivided into eight groups:

I Postoperative or case fatalities.
II Death without operation or irradiation.
III Operation followed by no irradiation.
IV Operation followed by inadequate irradiation.
V Operation followed by irradiation of cerebellar area *only*.
VI Operation followed by irradiation of cerebellar area and spine.
VII Operation followed by irradiation of spine and ventricular system.
VIII Treatment by irradiation *only*.

This classification is based on our present knowledge of the clinical behavior and pathological anatomy of these lesions. No explanation is needed for the first three groups. Group IV includes all those cases which were undertreated during our early experimental years of uncertainty in dealing with these lesions. The inadequacy of treatment was due both to a deficiency in knowledge of the characteristics of the tumor and to lack of equipment. There is also included in this group several cases who did not cooperate by returning at the proper time for their appointments, and a few cases that were not accessible to deep therapy machines.

Groups V and VI include most of the cases that were treated during the interval from 1925 until the adoption, in 1930, of our present routine technique.

All of the cases included in Groups VII and VIII had irradiation to the ventricular system during the course of treatment, but not in all the cases was it given at the time of the initial series.

TABLE I

THE RESULTS IN A SERIES OF 61 CASES OF CEREBELLAR MEDULLOBLASTOMATA

Group	Number of Cases	Average Postoperative Duration of Life in Months
I	19	0
II	2	0
III	14	5.6
IV	12	16.7
V	5	17.0
VI	6	15.1
VII	3	34.8*
VIII	0	0

* One patient living and symptom-free 82 months.

Table 1 gives the results in the series reported by Dr. Cushing[12] in 1930. All of these are dead except one, Folmsbee, Case 60.

This patient had, on November 15, 1928, a radical extirpation of a large medulloblastoma from the region of the roof of the fourth ventricle. This was followed by a series of roentgen treatments beginning December 8, 1928. Six treatments of 300 r each were given to the cerebellar area and the entire spine. The patient was discharged from the hospital in fairly good condition after the termination of the radiation

therapy. During the following year, 1929, he was given a total of six series of treatments to the cerebellar area. Each series was completed by two treatments, 300 r each. He was given two similar series in January and March of 1930.

The patient returned to the Tumor Clinic on October 31, 1931, with slight evidence of recurrence of the tumor as evidenced by recent nausea and vomiting. Dr. Cushing advised irradiating the entire ventricular system as well as the spine. A series of eight treatments, 200 r each, four to the ventricular system and four to the spine, including the cerebellar area, were given.

The patient has had no further irradiation. He has been seen at regular intervals in the Tumor Clinic.

TABLE II

RESULTS IN 13 CASES REPORTED IN THIS SERIES

Group	Number of Cases	Case Numbers	Average Postoperative Duration of Life in Months
I	1	III	0
II	0		0
III	0		0
IV	2	IV, IX	14.0
V	0		0
VI	3	I, V, VII	22.6*
VII	7	II, VI, VIII, X, XI, XII, XIII	30.7†
VIII	0		0

* One living 58 months postoperative. Condition good.

† One living and symptom-free 46 months postoperative.

TABLE III

RESULTS IN 7 CASES REPORTED IN THIS SERIES

Group	Number of Cases	Case Numbers	Average Postoperative Duration of Life in Months
I	0		0
II	1	XX	0
III	0		0
IV	2	XV, XVI	13.5
V	0		0
VI	0		0
VII	2	XVIII, XIX	10.5*
VIII	2	XIV, XVII	19.5†

* Both living and symptom-free 10 and 11 months.

† One symptom-free 35 months.

TABLE IV

FINAL ANALYSIS OF 81 CASES OF CEREBELLAR MEDULLOBLASTOMATA

Group	Number of Cases	Average Duration of Life in Months
I	20	0
II	3	0
III	14	5.6
IV	16	15.9*
V	5	17.0
VI	9	18.7†
VII	12	28.2‡
VIII	2	16.5§

* One died one month postoperative of meningitis.

† One living 58 months. Second operation.

‡ Four living 82, 46, 11 and 10 months.

§ One symptom-free 35 months.

The last examination was August 15, 1935. His condition at that time was quite satisfactory. There had been no recurrence of symptoms. Except for slight ataxia and a persisting nystagmus the examination was grossly negative.

Tables II and III enumerate the present status of the 20 cases reported in this series. Table IV gives the final analysis of the entire series of 81 cases of cerebellar medulloblastomata (Fig. 2).

SUMMARY

We believe that the data presented in this series of cases is sufficient to convince

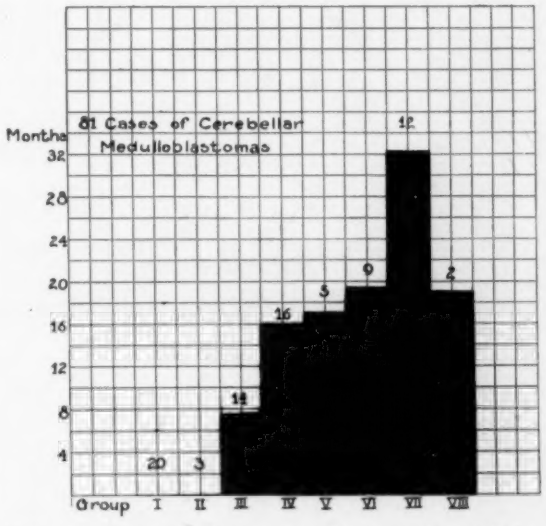
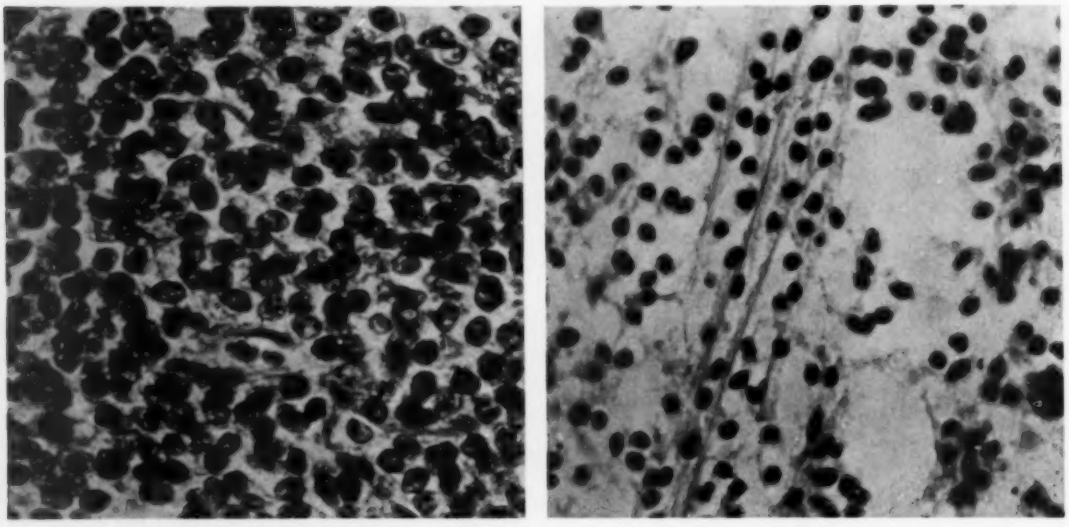


FIG. 2. The average postoperative duration of life in months according to groups.

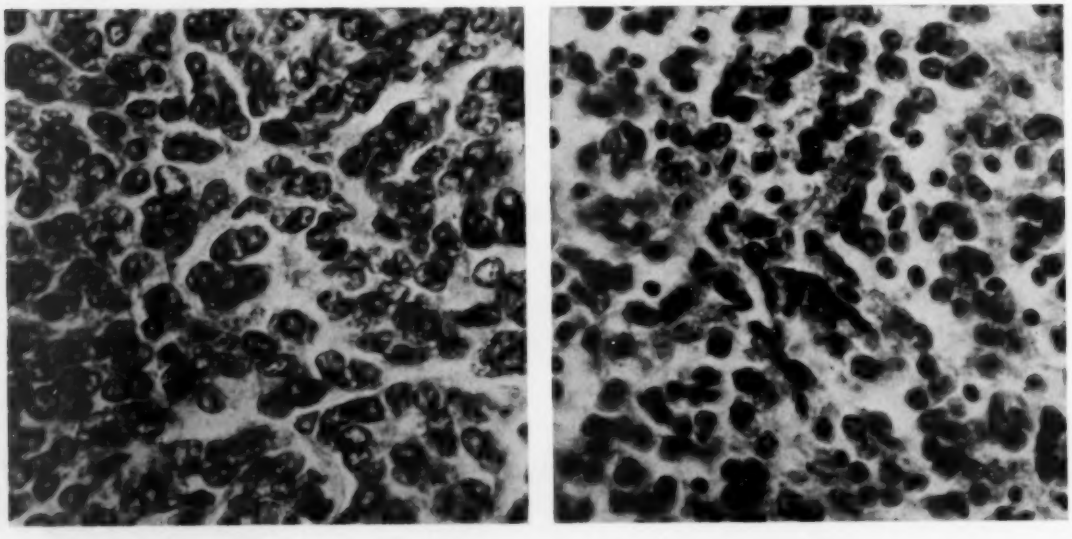
surgeons that radical extirpation of medulloblastomata is futile (e.g., Case XII). Irradiation without decompression is not contraindicated in selected cases of medulloblastoma suspects, providing there is close cooperation between the neurological surgeon and the radiologist.

The importance of irradiating the spine and ventricular system is verified clinically by our classification of cases showing the prolongation of the average duration of life with the development of our present technique. The significance of this technique is demonstrated pathologically by Cases VIII (Fig. 3), XII (Fig. 4), and XX. All of these showed a diffuse seeding of the tumor along the subarachnoid space of the spinal cord (Fig. 5) and over the cerebrum,



A *B*

FIG. 3. Photomicrographs from Case VIII. *A*. Tissue removed at operation. *B*. Tissue from cranial vault obtained at autopsy. Note the shrinkage of the cells due to the irradiation. ×610.



A *B*

FIG. 4. Photomicrographs from Case XII. *A*. Tissue removed at operation. *B*. Tissue obtained at autopsy. Note the shrinkage of the cells due to irradiation. ×610.

as well as into the third and lateral ventricles. Invasion of the bone is rare, and is apparently due to direct extension of the neoplasm.

We realize that the number of cases contained in Group VIII which were treated by irradiation alone is too small to draw any conclusions as to the efficacy of this method of treatment; however, we do believe that the conclusions derived from our analysis of this entire series of 81 cases justifies the adoption of this new technique. Time alone, with the collection of many other cases, will be necessary to confirm or disprove our conclusions.

CONCLUSIONS

1. Roentgen therapy offers the only hope for the cure of medulloblastomata.
2. Roentgen therapy may be given without a decompression.
3. Irradiation may be used in certain selected cases as a therapeutic test for differential diagnosis in medulloblastoma suspects.
4. Roentgen therapy to the ventricular system and the entire spine, as well as to the cerebellum, is essential.
5. The rapidity of growth of the tumor is apparently not altered by the age of the patient.

We are indeed indebted to Drs. R. E. Gross and O. T. Bailey, Residents in Pathology at the Peter Bent Brigham Hospital, for their kind assistance in the study of the pathological material herein presented.

REPORT OF CASES

Case I (S-34721). *Medulloblastoma, cerebellar. Biopsy. Roentgen therapy; no response. Death eight weeks following operation. No necropsy.*

R. Y., male, aged sixteen; admitted August 29, 1929. Complaints: severe headaches, vomiting without nausea, one year's duration, worse two months prior to admission; blurring of vision, transient amblyopia four months; diplopia two months; dizziness and unsteady gait six weeks.

Physical Examination. Bilateral papilledema; incoordination of ocular movements; third, fourth, and sixth nerve palsy; slight ataxia; hyperactive reflexes.

Ventriculogram Interpretation. Evidence of posterior fossa block.

Operation. Cerebellar exploration; adherent dura; tumor nodules at surface of left cerebellar hemisphere; biopsy.

Roentgen Therapy. Begun sixth postoperative day; two treatments, 315 r each, over cerebellum; four treatments 250 r each over cervical, thoracic and upper lumbar spine. Total dose, 500 r to each portal.

Brother reported no improvement; death in coma after six weeks.

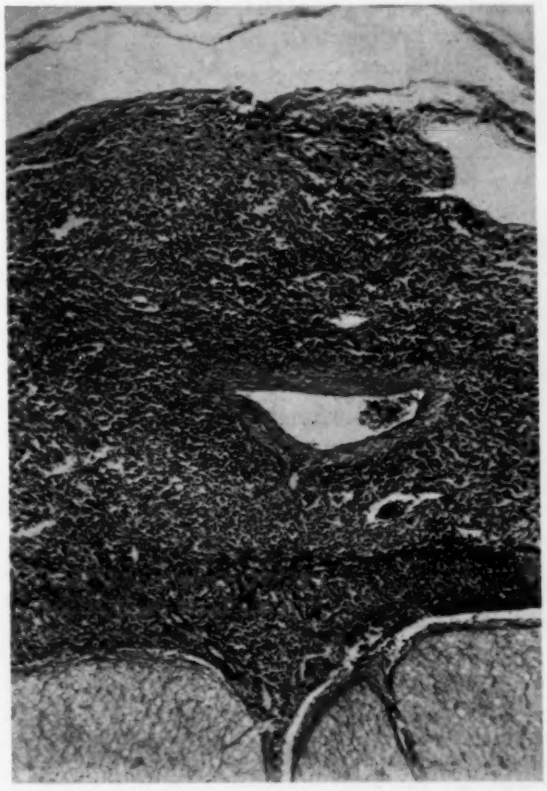


Fig. 5. Section of spinal cord, Case XII. Note the implantation of the tumor along the cord without invasion. ×50.

Histology. Fairly well differentiated cells with numerous mitotic figures. Impression: Quite typical of medulloblastoma.

Discussion. No explanation for failure to respond to irradiation.

Case II (S-34914). *Medulloblastoma, cerebellar. Extirpation. Roentgen therapy; improvement. Death three years following operation. No necropsy.*

F. A., female, aged thirty-two; admitted September 26, 1929. Complaints: headaches three months; failing vision and vomiting two months; dizziness, staggering gait, impaired

hearing on the right, one month; numbness right half of face two weeks.

Physical Examination. Slightly dilated pupils, react poorly to light and accommodation; hemorrhagic papilledema, hyperesthesia over distribution right fifth nerve; impaired hearing on right; sluggish deep reflexes.

Roentgen Interpretation. Skull negative.

Operation. Cerebellar exploration; large portion of vascular right cerebellar tumor extirpated.

Roentgen Therapy. Eighth and ninth postoperative days, 375 r each day over right cerebellar hemisphere; discharge condition good. No complaints two months later. Twenty-three months postoperatively: Dizziness, unsteadiness on feet; general weakness; right suboccipital region tender and swollen; ataxia. Two treatments, 375 r each, over cerebellum; symptoms disappeared within two weeks. Two months later condition good; four treatments, 315 r each, over ventricles. Thirty-six months postoperatively complaint: Dizziness and unsteady gait; examination: ataxia, incoordination on right; one treatment, 300 r, over cerebellum.

Husband reported paralysis of patient's right side following treatment; death in coma the following evening.

Histology. Vascular tumor; predominance of neuroblasts; great amount of struma; numerous mitotic figures. Impression: Medulloblastoma.

Discussion. Although inadequate, the roentgen therapy probably accounted for the long period of quiescence. The rapid progression of symptoms following the last treatment may be accounted for on the basis of the tumor causing a partial posterior fossa block, the edema resulting from irradiation was sufficient to complete the block.

Case III (S-36353). *Medulloblastoma, cerebellar. Extirpation. Roentgen therapy. Re-exploration. Death two weeks following second operation. Necropsy.*

R. B., male, aged nine, admitted April 28, 1930. Complaints: Headaches, vomiting, unsteadiness in walking two months; sore neck two weeks, intermittent hemiparesis.

Physical Examination. Papilledema, left nystagmus, hypotonicity with ataxia of extremities.

Roentgen Interpretation. Increased intracranial pressure.

First Operation. Cerebellar exploration, large fourth ventricle tumor extirpated.

Roentgen Therapy. Second to ninth postoperative day, 90 r daily; total 360 r over cerebellum; papilledema increased.

Second Operation. Tenth postoperative day; large blood clot overlay operative site. Stormy postoperative course; marked hyperthermia, draining sinus from operative wound. Death on eighteenth postoperative day.

Necropsy. Extensive staphylococcus meningitis; no tumor metastases.

Histology. First operation: Cells uniform in size, numerous mitotic figures, more or less perivascular arrangement. Some pseudo-rosettes. Impression: Medulloblastoma. Second operation: Marked degeneration of tumor cells, but few mitotic figures. Nuclei hyperchromatic, healthy appearing tumor cells seen. Impression: Medulloblastoma, following irradiation.

Discussion. The histological changes subsequent to irradiation 360 r, demonstrates how sensitive the tumors are.

Case IV (S-36933). *Medulloblastoma, cerebellar. Partial extirpation. Roentgen therapy; improvement. Death one year following operation. Necropsy.*

H. S., male, aged thirty-three, admitted July 18, 1930. Complaints: Tendency to fall to left eighteen months; clumsiness of the upper extremities one year; frontal headaches with projectile vomiting ten months; difficulty in talking and swallowing eight months.

Physical Examination. Mental changes; bilateral papilledema, exophthalmos; nystagmus; ataxia, dysmetria, hypotonicity of extremities; suboccipital tenderness and right hypoglossal palsy.

Roentgen Interpretation. Negative skull.

Operation. Cerebellar exploration; vascular midline tumor; excision impossible.

Roentgen Therapy. Thirteenth and fourteenth days postoperatively, 375 r each over cerebellar area, repeated six weeks later; improvement. Three months postoperatively four treatments, 315 r each, total 630 r over each of two portals covering entire spine. Two months later complaints: Vomiting; failure of vision; ataxia; treatments 375 r, over cerebellum. One year postoperatively physician reported death in Chelsea Hospital.

Necropsy. Cerebellum necrotic, no tissue saved.

Histology. Good cellular differentiation and few mitotic figures. Impression: Cerebellar medulloblastoma, relatively benign type.

Discussion. The patient received inadequate roentgen therapy.

Case v (S-36627). *Medulloblastoma, cerebellar. Subtemporal decompression; temporary relief; cerebellar exploration; diagnosis by lumbar puncture. Roentgen therapy; improvement. Death eight months following operation. No necropsy.*

S. R., male, aged thirty-five, admitted June 5, 1930. Complaints: Headache, vomiting, stiff neck for three months; blurring of vision, and crampy pains in neck and lower extremities two months.

Physical Examination. Left anosmia, bilateral papilledema.

Ventriculogram Interpretation. Evidence of posterior fossa block.

First Operation. Right subtemporal decompression; temporary relief.

Second operation one month later; cerebellar exploration; pea-sized tumor of vermis; not biopsied; operative diagnosis, medulloblastoma.

Roentgen Therapy. Two treatments, 375 r each, to cerebellum.

Third Operation. Re-exploration; one month later, leptomeningeal cyst; tumor nodule had disappeared; stormy convalescence; lumbar puncture for increased pressure; needle plugged with cellular débris.

Roentgen Therapy. Three weeks postoperatively, two treatments, 375 r each, over cerebellum; four treatments, 375 r each, over spine. Marked improvement, examination six weeks later negative except for marked ataxia. Four treatments, 315 r each, over spine. Examination six weeks later; bilateral optic atrophy, atrophy of the lower extremities, reflexes hyperactive; four treatments, 315 r each, over spine, and cerebellum. Progressive decline and death eight months postoperative. No necropsy.

Histology. Débris from lumbar puncture: Cells grouped in masses, generally round with round or oval nuclei, mitotic figures numerous. Impression: Medulloblastoma, very malignant.

Discussion. Temporary improvement followed decompression; recurrence of symptoms despite roentgen therapy, due to posterior fossa block. Irradiation caused tumor nodules described at second operation to disappear in three weeks. Despite the improvement this case received inadequate roentgen therapy.

Case vi (S-37260). *Medulloblastoma, cerebellar. Extirpation. Roentgen therapy; improvement. Death seventeen months following operation. No necropsy.*

E. H., male, aged five; admitted September 11, 1930. Complaints: Recurrent attacks of vomiting two and one-half months; frequent, severe, generalized headaches relieved by vomiting, slight clumsiness of arms and legs two months.

Physical Examination. Large head, cracked-pot resonance, occipital tenderness, acute papilledema, bilateral ataxia, internal strabismus.

Roentgen Interpretation. Increased intracranial pressure.

Operation. Cerebellar exploration; large tumor of vermis; metastatic tumor mass in right hemisphere; partial extirpation.

Roentgen Therapy. Ten to fifteen days postoperative, daily treatment 375 r, twice over cerebellum; four treatments, 315 r each, over spine, through two portals; improvement. Two months later two treatments, 250 r each, over cerebellum; improved except for suboccipital headaches. Six months later: vomiting and headache; examination negative, two treatments, 250 r each, over cerebellum.

Nine months postoperative, recurrence of original symptoms; bilateral papilledema, ataxia; vomiting. Four treatments, 315 r each, over ventricles; immediate improvement. Treatment repeated six weeks later; further improvement. Five months later marked recurrence of symptoms; two treatments, 250 r each, over cerebellar area; no improvement. Death seventeen months postoperative. No necropsy.

Histology. Cells small, uniform in size, mitotic figures numerous. Impression; Typical medulloblastoma.

Discussion. The growth of the tumor was checked by the irradiation to the ventricular system. Not enough therapy was given to retard the neoplasm permanently, possibly remnants of tumor tissue caused a mechanical block.

Case vii (S-37696). *Medulloblastoma, cerebellar. Partial extirpation. Roentgen therapy; living four years and ten months following operation.*

G. F., female, aged thirty-seven, admitted November 20, 1930. Complaints: Dizziness, nausea and vomiting on sudden motion of head two years; prolonged, severe frontal headaches six months; blurring of vision, diplopia six weeks; numbness right face five weeks; slurring speech four weeks.

Physical Examination. Acute bilateral papilledema, nystagmus; ataxia of right arm, staggering.

Roentgen Interpretation. Erosion of posterior clinoids.

First Operation. Cerebellar exploration; negative; no improvement.

Second Operation. Two weeks later, partial extirpation tumor right cerebellum.

Roentgen Therapy. Begun seven days postoperative; four treatments 315 r each, two over cerebellum, two over dorsal and lumbar spine; improvement. Two months later 300 r over cerebellum and 520 r over spine. Treatments of unknown quantity given ten times during next three years. Four years postoperative sudden recurrence of ataxia and slurring speech.

Third Operation. (University of California Hospital.) Four and one-half years after first exploration large cerebellar tumor removed; improvement.

Histology. First surgical specimen: Cellular tumor composed of cords, masses and clusters of oval and round, occasionally pyriform, cells of uniform size and type, definitely blastic in nature, numerous mitotic figures. Impression: Medulloblastoma, very malignant. Second surgical specimen: Similar to first specimen; definite increase in stroma. No necrosis or cystic degeneration.

Discussion. The period of freedom from symptoms demonstrates the desirability of intensive irradiation in the treatment of medulloblastoma. Possibly the recurrence might have been delayed had irradiation been heavier and had included the ventricular system. The tumor found at the second operation lay under an unepilated area of the scalp.

Case viii (S-38065). *Medulloblastoma, cerebellar. Extirpation. Roentgen therapy; improvement. Death three and one-half years following operation. Necropsy.*

J. E., male, aged nineteen, admitted January 21, 1931. Complaints: Occasional vomiting four years; frontal headaches, dizziness one year; morning vomiting followed by suboccipital headache six weeks; transient blurring of vision one month.

Physical Examination. Bilateral papilledema; nystagmoid ocular movements.

Ventriculogram Interpretation. Evidence of posterior fossa block.

Operation. Suboccipital exploration: Partial extirpation small tumor.

Roentgen Therapy. Nine days postoperative, daily treatments, two 300 r each, over cerebellum; four 250 r each, over entire spine; improvement. Treatment repeated after fourteen weeks and after seven months; continued improvement; returned to work as garage mechanic. Eight months postoperative, two treatments, 300 r each, over cerebellum.

Condition satisfactory for three years, only symptoms morning vomiting and occasional epileptiform seizure; abrupt return of double vision, headache, nausea and unsteadiness. Physical examination: Lateral nystagmus, dilated pupils, and bilateral papilledema. Two treatments, 200 r each, over cerebellum; four 250 r each, over ventricles; four treatments over spine. Four months later initial series repeated; marked reaction, evidence of increased intracranial pressure, disorientation. Two months later, treatments over ventricles and spine; temporary improvement. One month later, 200 r, over cerebellum, one month later six treatments, 250 r each, over cerebellum and ventricles; no symptomatic relief. Death forty-two months postoperative.

Necropsy. Small tumor right frontal region had eroded tables of cranium. Tumor seeded throughout ventricular system, along base of brain, subarachnoid space of spinal cord, and nerve roots. Little evidence of fibrosis.

Histology. Spinal fluid from operation: tumor cells found. Cells uniform, compact composition, elongated to oval in shape, accompanied by abundance of sharp fine neuroglia fibers. The neuroglia fibers are scarce where cells are oval to round. Typical of medulloblastoma. Mitotic figures are scarce. Impression: Medulloblastoma.

Necropsy. Widespread invasion of cerebellum, variation in size and shape of cells; predominance of certain cell types in different areas. Cytoplasm scanty, irregular and shrunken, nuclei pyknotic. Impression: Typical medulloblastoma; marked contrast of autopsy material with that of the original sections probably the result of roentgen treatments (Fig. 3).

Discussion. It is questionable whether life could have been prolonged had roentgen therapy been given at intervals during the period from May, 1931, to October, 1933. The recurrence of the symptoms was typical in that they resulted from rapid growth with evidence of diminished response to irradiation. The pain in the extremities did not occur until the tumor extended along the nerve roots. The invasion

of the ventricular system is typical of medulloblastomas and indicates the necessity for intensive irradiation of the ventricular system. There was little fibrosis found at necropsy.

Case IX (S-38712). *Medulloblastoma, cerebellar. Extirpation. Roentgen therapy. Death sixteen months following operation. No necropsy.*

P. T., male, aged eleven, admitted April 27, 1931. Complaints: Mental impairment, awkwardness in gait, easy fatigue five months; frontal headaches, failing vision two months; incontinence of urine two weeks.

Physical Examination. Bilateral papilledema, blindness O. S. diminished acuity O. D., nystagmus; right facial weakness; ataxia, and asynergia of arms and legs, bilateral Babinski, staggering gait; mentality very low.

Roentgen Interpretation. Skull; marked signs of increased pressure.

Operation. Cerebellar exploration; radical extirpation huge soft medulloblastoma involving vermis. Marked hyperthermia for twelve hours.

Roentgen Therapy. Fifth to eighth postoperative days, daily treatments, 315 r each, over spine and cerebellum. Discharge condition poor; blind on left; very poor vision on right; marked dysarthria; constant nystagmus, and ataxia. Fourteen months postoperative symptoms recurred. Treatment afforded temporary improvement. Death sixteen months postoperative. No necropsy.

Histology. Small, poorly defined cells with small fascicular nucleus, and prominent nucleolus; little stroma; mitotic figures of compact type. Impression: Malignant medulloblastoma.

Discussion. The unfortunate delay in proper irradiation following discharge was responsible for the early return of symptoms. The irradiation given was probably inadequate.

Case X (S-39813). *Medulloblastoma, cerebellar. Partial extirpation. Roentgen therapy; improvement. Death fifteen months following operation. No necropsy.*

C. R., male, aged thirteen, admitted October 13, 1931. Complaints: Fronto-occipital headaches eight months; severe two months; ataxia and vomiting two months; drowsiness one month, double vision three days.

Physical Examination. Head tilted to right and forward; horizontal and vertical nystagmus, acute bilateral papilledema; marked ataxia; Romberg; visual acuity low.

Roentgen Interpretation. Skull, negative.

Operation. Suboccipital exploration; partial extirpation of soft tumor overlying roof of fourth ventricle.

Roentgen Therapy. Fourth to ninth day postoperative, two treatments, 325 r each over cerebellum, two treatments, 270 r each, over spine, two 250 r each, over ventricles; improvement. Four weeks later treatment over cerebellum repeated. Four months later condition satisfactory; examination negative; initial treatment repeated. Rapid recurrence of symptoms after six months' freedom; bilateral papilledema, ataxia, Romberg; nystagmus. Irradiation repeated; marked temporary improvement. Death fifteen months postoperatively.

Histology. Cells fairly well differentiated; few mitotic figures. Stroma prominent. Impression: Medulloblastoma.

Discussion. This patient received adequate irradiation with only temporary amelioration of the original symptomatology. The possibility of fibrosis, due to the irradiation, causing the early recurrence of symptoms cannot be considered in view of absence of fibrosis at necropsy in Cases VIII and XII. Histology is quite similar to that of Case XI yet there was a great difference in response to irradiation.

Case XI (S-39998). *Medulloblastoma, cerebellar. Extirpation. Roentgen therapy; asymptomatic three years and ten months following operation.*

F. P., male, aged twelve, admitted November 10, 1931. Complaints: Severe frontal headaches, stiffness of neck six weeks, failing vision three weeks, vomiting without nausea two weeks, double vision five days.

Physical Examination. Papilledema, left abducens palsy; bilateral nystagmus; right Babinski; Romberg; broad-based station.

Roentgen Interpretation. Skull, signs of increased intracranial pressure.

Operation. Suboccipital exploration; extirpation of tumor from beneath vermis.

Roentgen Therapy. Sixth to ninth postoperative days, four treatments, 315 r each, over cerebellum and spine; four treatments 250 r each over ventricles. Examination: Six weeks later, hyperactive reflexes; two treatments, 315 r each, over cerebellum. Examination negative six months later; treatments repeated; no recurrence of tumor evident. Last seen three years and ten months after operation; patient completely asymptomatic, physical examination negative.

Histology. Poor cellular differentiation; numerous mitotic figures. Impression: Medulloblastoma.

Discussion. This case illustrates the ideal response to surgery and irradiation. Irradiation to the ventricular system may be the fortunate factor in the retardation of growth.

Case xii (S-40028). *Medulloblastoma, cerebellar. Radical extirpation; rapid recurrence. Roentgen therapy; improvement. Death two years and eleven months following operation. Necropsy.*

K. F., male, aged twenty-nine, admitted November 14, 1931. Complaints: Sudden onset of suboccipital headaches followed by dizziness, six weeks; vomiting four weeks; poor vision three weeks; unsteadiness of gait two weeks.

Physical Examination. Bilateral papilledema; dilated pupils; Romberg; unsteady gait; generalized hypotonicity; unable to stand alone.

Roentgen Interpretation. Skull, negative.

Operation. Radical extirpation of cerebellar tumor. Roentgen therapy not recommended. Three months later symptoms recurred.

Roentgen Therapy. Six treatments, 200 r each, over cerebellum and spine. One week later four treatments, 222 r each, over ventricles; marked improvement. Three months later, two treatments, 250 r each, over cerebellum; repeated after six months; condition satisfactory. Four months later, complaints: blurring of vision; pain in back; ataxia; tenderness along spine. Four treatments, 250 r each, over cerebellum and spine; repeated six weeks later; four treatments, 250 r each, over ventricles; slight improvement. Two months later because of increasing pain in the back, six treatments, 250 r each, over entire spine; prompt relief.

Twenty-five months postoperative; headache, nausea, vomiting, pain in the back, blurring of vision, unsteadiness gradually recurred. Persisted until death eleven months later. During the interval twelve treatments, 250 r each, given over spine and ventricles.

Necropsy. Skin adherent over cerebellum; cerebellum diffusely infiltrated with tumor; metastatic tumor nodules over temporal and frontal lobes, cerebellum, and spinal cord.

Histology. Surgical specimen: Medium-sized epithelioid cells with ovoid nuclei, in oval and glomerular-like clusters and bizarre cords or columns; minimal amount of stroma; occasional mitotic figures; no neuroblasts or spongioblasts seen. Impression: Atypical medulloblastoma.

Necropsy. Cells showed cord-like arrangement with minimum stroma. Striking change in size of cells. Large numbers of pyknotic nuclei. Mitotic figures fewer. Poor differentiation of astroblasts and neuroblasts (see Fig. 4). Radiodermatitis of skin. Tumor seeded along subarachnoid space without invasion of cervical cord (see Fig. 5). Impression: Necropsy. Fairly malignant medulloblastoma.

Discussion. Irradiation was not given postoperatively to determine value of complete removal by electrosurgery. Operative removal was complete. The early recurrence is evidence that complete removal is impossible and exemplifies the futility of surgical treatment. The cellular changes can be attributed to irradiation.

Case xiii (S-41255). *Medulloblastoma, cerebellar. Extirpation; roentgen therapy; improvement. Death two years following operation. No necropsy.*

D. B., male, aged six, admitted May 31, 1932. Complaints: Headaches, dizziness, vomiting, stiffness of the neck four months; unsteady, staggering gait three months; transient right hemiplegia five days.

Physical Examination. Hydrocephalic head; papilledema; dilated pupils; horizontal and vertical nystagmus; partial left sixth nerve palsy; Romberg; staggering gait.

Roentgen Interpretation. Skull, evidence of increased pressure.

Operation. Suboccipital exploration; large tumor removed from roof of fourth ventricle.

Roentgen Therapy. Begun second preoperative day, treatments 250 r each, over cervical, dorsal spine; eleven days postoperative, three treatments, 250 r, over cerebellum, and four, 250 r, over ventricles. Treatment repeated two months later and ten months later. Nineteen months later symptoms gradually recurred; treatment ineffective. Death two years postoperative. No necropsy.

Histology. Vascular tumor; predominance of glial tissue. Impression: Medulloblastoma.

Discussion. Irradiation adequate. The growth of the tumor was retarded by the initial series of treatments, but apparently the tumor became more resistant.

Case xiv (S-42184). *Medulloblastoma, cerebellar suspected. No operation. Roentgen therapy. Asymptomatic two years and eleven months following irradiation.*

H. F., female, aged thirteen, admitted October 19, 1932. Complaints: Frontal headaches, dizziness seven weeks; twitching left face, dip-

lopia, weakness of knees two weeks, chest pain, not related to respiration, one week.

Physical Examination. Bilateral papilledema, slight paresis left lower face; muscular hypotonicity, diminished deep reflexes.

Ventriculogram Interpretation. Slight uniform dilatation of all ventricles.

Diagnosis. Clinical features of medulloblastoma. Roentgen treatment advised as therapeutic test.

Roentgen Therapy. Three treatments, 190 r each, over cerebellum; improvement. Six weeks later, asymptomatic, good muscle tone. Two treatments, 320 r each, over cerebellum; improvement. Six weeks later; epistaxis, papilledema, continued school. Four months later, treatment 600 r each over ventricles, cerebellum, spine.

One year following initial treatment sudden obstipation followed by nausea and vomiting, treatment, 600 r, over ventricles, cerebellum and spine. Well, continued school and worked as waitress. Examination three years following onset unremarkable except for hyperactive reflexes.

Discussion. The immediate response to irradiation is indicative that the diagnosis of medulloblastoma is correct in view of the patient's age and cerebellar symptomology. The differential diagnosis of cerebellar tumor in this age group must consider fibrillary astrocytoma which does not respond to roentgen therapy.

Case xv (S-42313). *Medulloblastoma cerebellar. Extirpation. Roentgen therapy; improvement. Death one year following operation. No necropsy.*

G. J. LaC., male, aged twenty-five, admitted November 8, 1932. Complaints: Headaches five months; dizziness four months; blurred vision six weeks; staggering gait five weeks; nausea and vomiting three weeks; and bilateral tinnitus on sudden motion recent.

Physical Examination. Coarse lateral nystagmus; papilledema; exaggerated deep reflexes; Romberg to left.

Roentgen Interpretation. Ventriculogram; uniform dilatation of ventricles with tumor projecting into fourth.

Operation. Suboccipital exploration; large tumor in the roof of the fourth ventricle biopsied.

Roentgen Treatment. Begun thirteenth postoperative day; eight treatments, 375 r each, four over spine and cerebellum; four over ventricles; improvement. Complaints: Two months later occasional morning vomiting, headaches; examination negative; two treatments, 250 r each, over cerebellum.

Ten months postoperative, symptoms returned: Ataxia, severe headaches, morning vomiting; eight treatments, 315 r each, over spine and ventricles; immediate improvement. Death two months later. No necropsy.

Histology. Closely packed, fairly uniform small cells without definite arrangement but suggestive rosette formation; nuclei round, or star-shaped with few mitotic figures. Rare neuroblasts and spongioblasts. Impression. Medulloblastoma.

Discussion. This case demonstrates how rapidly these tumors progress to a fatal termination. It is quite possible that the neoplasm had become radioresistant and further irradiation would have been valueless.

Case xvi (S-42388). *Medulloblastoma cerebellar. Extirpation. Roentgen therapy; improvement. Death one year and three months following operation. No necropsy.*

D. M. B., female, aged eleven, admitted November 19, 1932. Complaints: Frontal and suboccipital headaches, uncertain gait three months; diplopia, projectile vomiting one month.

Physical Examination. Head tilted to left; bilateral papilledema; enlarged blind spot, nasal defect O. D.; coarse, sustained nystagmus to left, weakness of sixth cranial nerves; slight nerve deafness on left; ataxia and hyperactive reflexes.

Roentgen Interpretation. Skull, increased pressure. Atrophic posterior clinoids.

Operation. Suboccipital extirpation; large tumor removed from roof of fourth ventricle. Suggestive symptoms: Esophageal, or gastric ulcers, about the ninth postoperative day.

Roentgen Treatments. Begun ninth postoperative day, eight treatments, 250 r each, four over ventricles; four over spine; improvement. Two months later symptoms recurred; treatment repeated; prompt relief for seven months. Treatment repeated; no improvement. Death fifteen months postoperative. No necropsy.

Histology. Closely packed, moderately large cells without definite arrangement, and minimum amount of stroma and vascular supply; few spongioblasts but no neuroblasts; numerous mitotic figures. Impression: Medulloblastoma, fairly malignant.

Discussion. The tumor responded very well to the first irradiation but apparently became radioresistant.

Case xvii (S-47284). *Medulloblastoma cerebellar. No operation. Roentgen therapy; temporary improvement. Death eight months after onset of symptoms. Necropsy.*

J. V. R., male, aged fifteen, admitted May 23, 1934. Complaints: Headaches five months; weakness of right hand and leg, slurring speech, staggering gait two months; double vision for one month; projectile vomiting for two weeks.

Physical Examination. Bilateral papilledema; internal strabismus, bilateral nystagmus; ataxia; right hemiplegia; general condition poor.

Roentgen Therapy. Ten treatments were given, 200 r each, over ventricles and spine, totaling 400 r each of five portals. No systemic reaction; improvement. Five weeks later, marked improvement; papilledema less, speech and ataxia improved; able to walk alone. Two treatments, 250 r each over cerebellum; rapid recurrence of symptoms; six weeks later admitted in coma.

Ventriculogram Interpretation. Posterior fossa block.

Roentgen Treatment. Improvement for five days following ventriculography. Two treatments, 250 r each, over alternate sides of head; patient became comatose; died.

Necropsy. Extravasation of blood over cerebrum; convolutions flat; tumor, 4.5×6 cm., involving the brain stem.

Histology. Cellular glioma; prominent glial meshwork, lacking typical findings of medulloblastoma. No mitotic figures seen. Impression: Probably medulloblastoma. Microscopic appearance attributed to irradiation.

Discussion. The rapid onset of symptoms and their steady progression along with the typical physical findings led to the diagnosis of cerebellar medulloblastoma. Because of the patient's poor condition, irradiation, without surgery, was advised. The rapid recurrence of symptoms prompted ventriculography in an attempt to verify the diagnosis. Ventriculography was the immediate cause of the patient's death.

Case xviii (S-47632). *Medulloblastoma cerebellar. Biopsy. Roentgen therapy; asymptomatic ten months following operation.*

E. M., male, aged sixteen, admitted October 26, 1934. Complaints: Occasional vomiting five years, projectile on one occasion; stiff neck three months; headaches six weeks; strabismus O. S., two weeks.

Physical Examination. Dilated equal pupils; nystagmus; right abducens paresis; bilateral hemorrhagic papilledema; stiff neck; deviation of the mandible to the left; hypoactive reflexes; Kernig and Romberg.

Roentgen Interpretation. Ventriculogram, posterior fossa block.

Operation. Cerebellar exploration, biopsied: Large tumor of roof of fourth ventricle infiltrating the right hemisphere.

Roentgen Therapy. Begun fifteenth postoperative day; six treatments, 250 r each, over spine and cerebellum; four treatments, 300 r each, over ventricles; improvement. Two months postoperative, two treatments, 375 r each, over cerebellum; four months postoperative, two treatments, 300 r each, over cerebellum; six months postoperative, original treatments repeated; nine months postoperative, three treatments, 320 r each, over cerebellum; visual acuity O. D. 6/200 and O. S. 20/200.

Histology. Cells uniform, small with scanty cytoplasm; mitotic figures are scarce. Impression: Medulloblastoma.

Discussion. The response of this tumor to irradiation is an indication of a very radiosensitive neoplasm although histologically it is the least malignant tumor of the series. Our program will be to give no further irradiation unless symptoms recur; following the destruction of the tumor the right cerebellar hemisphere may eventually cause symptoms from the remaining interstitial tissue. Both decompression and irradiation have failed to restore his vision. It is possible that the initial damage due to hemorrhagic retinitis is the factor causing the impaired vision. The five year history of vomiting was confusing and led to the preoperative diagnosis of astrocytoma. It seems inconceivable from the histological appearance that this tumor had been present for such a long period; however, the history in Case viii is quite similar, and there is marked similarity in the histological appearance.

Case xix (S-47744). *Medulloblastoma, cerebellar. Biopsy. Roentgen therapy; asymptomatic eight months following operation.*

J. R., female, aged fourteen, admitted November 12, 1934. Complaints: Intermittent projectile vomiting and staggering, progressive weakness one year; blurring vision, diplopia one

month; severe occipital headache, numbness of right half of tongue two days.

Physical Examination. Pallor, malnutrition, poor development. Visual acuity 20/100 O. S., 20/50 O. D., bilateral papilledema, internal strabismus O. S., rotary nystagmus; diminished taste anterior two-thirds, right half of tongue; suboccipital tenderness; ataxia, tendency to fall to right.

Ventriculogram Interpretation. Evidence of posterior fossa block.

Operation. Cerebellar exploration: biopsy of large tumor from roof of fourth ventricle.

Roentgen Therapy. Begun thirteenth day postoperative, twelve daily treatments, 150–250 r each, 620 r over each side of ventricular system, 760 r each of two spinal portals; improvement. Six weeks later; asymptomatic; nystagmus to left only; no Romberg. Two treatments, 375 r each, over cerebellum, repeated six weeks later. Eight months postoperative original series of treatments over ventricles and spine repeated.

Histology. Uniform small, round cells grouped in masses. Scanty cytoplasm, numerous mitotic figures. Impression: Medulloblastoma, fairly malignant.

Discussion. The immediate improvement could be attributed to decompression. The patient might have been treated without surgery if there had not been such rapid impairment of vision which might have resulted in irreparable damage.

Case xx (S-48256). *Medulloblastoma, cerebellar. No treatment. Death four months following onset. Necropsy.*

E. W. S., female, aged sixty-five, admitted January 25, 1935. Complaints: Onset of nausea, vomiting, headache, loss of memory four months. Diagnosed "nervous breakdown," symptoms and signs disappeared after several weeks' bed rest; blurring of vision and recurrence of occipital headache one month; nausea and vomiting, ataxia, loss of memory three weeks, stupor two weeks.

Physical Examination. Obesity, stupor, pupils contracted, sluggish to light and accommodation, left eye deviated laterally and upward, with ptosis and exophoria, bilateral papilledema; questionable left facial paresis; diminished reflexes in legs, more on right; right Babinski.

Ventriculogram Interpretation. Moderately dilated ventricles. Small round tumor protruding into third ventricle.

Course. Twenty-four hours following ventriculography respiratory rate suddenly slowed; pulse disappeared, death ensued.

Necropsy. Convolutions flattened; bulge in floor of third ventricle; diffuse softening of pons and medulla; left cerebral peduncle enlarged and soft, infiltrated with necrotic tumor; third, fourth ventricles, aqueduct of Sylvius, cerebellum invaded by tumor.

Histology. Cells small, round pyriform medulloblasts, few astrocytes. Impression: Malignant medulloblastoma.

Discussion. This case is unusual in that the patient is the oldest (aged sixty-five) reported in the literature in whom a medulloblastoma was verified. The rapid course of the disease is characteristic of this tumor.

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DISCUSSION

Dr. C. G. Dyke, New York City. It is a pleasure to discuss this paper. The views which have been expressed are very similar to my own and to those followed at the Neurological Institute of New York.

To Dr. Sosman and his coworkers at the Peter Bent Brigham Hospital goes the credit for pointing out the importance of treating the entire spine of patients with cerebellar medulloblastomas. Since the primary tumor frequently gives rise to cells which lodge in the meninges surrounding the spinal cord, thus producing secondary tumors, the entire spine is irradiated as a prophylactic measure in every case of medulloblastoma. It is the practice at the Neurological Institute to treat the spine as vigorously as the cranium. Ever since the patients have been treated in this way, I know of no case which has developed a secondary tumor in the spinal meninges. I would like, therefore, to ask Dr. Sosman if there are any cases in his series which have developed spinal metastases following roentgen therapy.

In my experience, the differential diagnosis between a cerebellar medulloblastoma and astrocytoma is not always possible from the history and neurological examination. Therefore, a patient with an astrocytoma will occasionally be treated with the roentgen rays if the lesion has not been histologically verified, and I believe that a certain percentage of these tumors will respond somewhat to roentgen therapy. It is known that they are not as radiosensitive as are the medulloblastomas, but I do not believe it is advisable to say that if a cerebellar tumor in a child responds to irradiation, it is a medulloblastoma, and if it does not, it is an astrocytoma. Moreover, since a large number of cerebellar astrocytomas are amenable to surgical procedures, valuable time would be lost in the treatment of the patient, even if it were a case which responded to irradiation. It is because of this that we feel every cerebellar tumor should be verified by histological examination, and if it is a medulloblastoma, a generous suboccipital decompression should be made followed by thorough roentgen therapy to the skull and spine. Radical extirpation of these tumors has not proved successful and therefore this should not be attempted as the mortality is too high and better results can be obtained by a conservative surgical procedure and adequate irradiation.

Dr. Temple Fay, Philadelphia. Dr. Sosman should be congratulated for taking the bold stand that he has in this problem. The foundation of a policy of treatment for cerebellar medulloblastomas vitally concerns the roentgenologist as well as the neurosurgeon. Such a policy, must, however, rest upon certain fundamental factors in cerebral hydrodynamics, as well as clinical results obtained by any method of treatment.

Inasmuch as patients suffering from cerebellar medulloblastomas present themselves in various stages of the disease and manifest a wide variety of physical and intracranial response to such lesions, frequently the paradox arises of few symptoms and a large lesion or acute signs from a relatively small tumor; the reports of cases observed, treated, or operated

upon and the end-results obtained can hardly be convincing where methods of treatment and technique have differed so widely as in the past.

Certain basic considerations in this problem have led me to the conviction that the radiologist must play the most important part in the treatment of these patients and that the duties of the neurosurgeon are primarily concerned with the satisfactory control and relief of the complicating increased intracranial pressure, so that the roentgenologist may have a fair opportunity of giving the necessary deep roentgen therapy particularly beneficial to this group.

SUBOCCIPITAL DECOMPRESSION AND IRRADIATION

	Patient	Age years	Postoperative Irradiation	Total r	Survival Period	End-result
1	R.B.	4½	3 series of 1,000 r each	3,000	36 months	Excellent, at school
2	R.McD.	12	1 series	?	20 months	Died
3	F.H.	17	4 series of 800 r each	3,200	23 months	Died
4	M.W.	1½	(No decompression); 1 series 500 r	500	3 months	Died

SUBOCCIPITAL DECOMPRESSION + TENTORIAL SECTION + IRRADIATION

1	J.B.	6	4 series of 1,000 r each	4,000	42 months	Excellent, at school
2	M.M.	17	3 series 800; 1,000; 1,000 r	2,800	36 months	Excellent, working
3	L.P.	4½	3 series 900; 1,000; 1,000 r	2,900	34 months	Excellent, at school
4	J.H.	9	2 series of 1,500 r	3,000	5 months	Very good, special school

The majority of neurosurgeons feel that surgery is required for tumor verification and removal should be attempted. I have favored the more conservative course.

Dr. Pancoast and Dr. Pendergrass will recall that over seven years ago Dr. Spiller and I referred two children suffering from typical signs of cerebellar medulloblastoma for deep roentgen therapy in preference to initial operation. These cases had advanced to the stage of choked disc with marked cerebellar manifestations.

Neurosurgical intervention at that time was considered the usual means of relief, but in view of the high surgical risk, because these patients were in their infancy, deep roentgen therapy was resorted to without decompression or exploration and marked and prompt clinical improvement followed. One of these children remained symptom-free for a period of two years when surgical intervention was required.

Since 1928, my experience with this group has led me to the conviction that deep roentgen therapy is the method of choice in cerebellar medulloblastoma.

Where patients are encountered with high choking of the discs and a dangerous degree of increased intracranial pressure, affecting the vital respiratory, vasomotor and cardioregulatory centers, the increased intracranial pressure problem demands neurosurgical correction in order that the roentgenologist may pursue the course of deep roentgen treatment without danger of interruption.

In my opinion, the crux of the situation arises at this point. The neurosurgeon has the choice of surgical methods for control of intracranial pressure during the acute phase. He must cooperate closely and intimately with the roentgenologist in the management of the problem. Ventricular drainage may be instituted and be of temporary benefit; a ventriculogram obtained at the same time to confirm the obstruction to the outlets of the fourth ventricle and establish the degree of internal hydrocephalus which is almost universally present when increased intracranial pressure signs have arisen. Repeated ventricular taps or the inter-

mittent placing of a ventricular cannula to establish drainage and reduce pressure may be sufficient to carry the patient through the period of deep roentgen treatment and subsequent readjustment.

Suboccipital decompression, if properly carried out, offers an ideal relief of acute pressure manifestations and at the same time gives an opportunity to release the cerebellar tissue that may have been forced into the foramen magnum, if the surgeon extends his decompression so as to include the lamina of the atlas. Opening the dura into the spinal canal will permit spontaneous decompression of the cerebellar hernia, if present. The decompression, in order to be complete and ideal, should include a section of the tentorium from the incisura to the lateral sinus and the opening of the dura above the lateral sinus on one or both sides.

This additional technical problem makes possible complete decompression into the cranial cavity above and releases the danger of obstruction caused by the incisura of the tentorium, in the event that the subsequent growth of the tumor may require more space than afforded by the suboccipital decompression alone.

The free invasion of the tumor tissue into the pons and region of the superior cerebellar peduncles often defeats the advantage gained by the suboccipital decompression alone, in that the original obstruction to cerebrospinal fluid escape into the posterior fossa is subsequently transferred to an obstruction at the incisura in the region of the cisterna pontis, presenting an insurmountable obstacle as time progresses.

The neurosurgeon, having accomplished a full decompression (both tentorially and spinally), has had an opportunity to view the cerebellar hemispheres and to determine the presence or absence of cystic arachnoiditis or astrocytoma in a cystic form. If obvious swelling of the hemisphere indicates the presence of medulloblastoma or intramedullary tumor substance, an exploratory cannula directed into the obvious mass should reveal a cystic collection. In my opinion, no attempt should be made to remove cerebellar tissue or attack the tumor mass if found to be solid and non-cystic.

Both the operative and postoperative risks are greatly increased the moment the surgeon disturbs or advances into the cerebellar substance and particularly as the operative field approaches the vital centers near the fourth ventricle in the region of the pons and medulla.

The following reasons have seemed to me sufficient to leave the tumor tissue undisturbed: (1) Rarely, if ever, is a medulloblastoma completely and successfully removed by the surgeon. (2) Almost invariably the patients who survive operative intervention are referred to the roentgenologist for subsequent deep roentgen therapy. (3) During the past few years it has become increasingly obvious that patients who are able to complete the full series of deep roentgen treatments by the "fractional method" have shown a longer period of survival and freedom from clinical symptoms of cerebellar dysfunction and increased intracranial pressure. (4) Surgical removal of cerebellar tissue does not relieve symptoms but in the destruction of the area invaded by tumor (if the tumor were responsible for the symptoms) then the surgical removal of the tumor and tissue would give no relief of cerebellar signs, but only serve to remove a volume of tissue sufficient to relieve the increased intracranial pressure. (5) That clinical symptoms improve following deep irradiation as well as following extirpation of the tumor mass indicates that the symptoms arose secondarily from the effects of the tumor and pressure, and not from the destructive tumor invasion, per se. Hence, deep roentgen therapy is to be preferred over surgical destruction of tissue, provided sufficient volume can be offered to the cranial cavity so that the effects of deep roentgen therapy may be carried on without loss of the patient from intracranial pressure symptoms alone. (6) In my experience, children under five years of age have tolerated the full decompressive measures, whereas an additional attack upon the tumor mass is associated with prompt or delayed symptoms that jeopardize the life of the patient. It is obvious from this small series referred to that full tentorial decompression offers additional clinical improvement and assurance of survival as well as an opportunity for appropriate roentgen therapy. (7) Proper fluid balance of the patient and appropriate dehydration as an adjunct to decompression have offered great relief from increased intracranial pressure symptoms and protected vision during the stage of recession of the discs. (8) The patients presented to the roentgenologist have suffered least from their neurosurgical experience and are in far better condition to maintain the subsequent period of irradiation than those subjected to decompression and tumor extirpation.

The majority of neurosurgeons justly raise the question that no confirmation of tumor tissue is possible if the lesion is not attacked and tissue removed for examination. In my opinion, the reply to this argument is that with a full exploratory decompression as outlined above, the neurosurgeon has had an opportunity to view the gross pathology, to deal with surface lesions or obvious cysts as part of his decompressive procedure and to establish the diagnosis of a cystic astrocytoma, if such be present.

Although astrocytomas are apparently not responsive to deep roentgen therapy, the problem again evolves itself into the question of adequate space, rapidity of growth, and full decompression, in order to relieve clinical symptoms. Where ample space is provided or adequate adjustments can be made in the intracranial volume relationships, astrocytomas have been known to be present for a period of over thirty years. The beneficial results assured from neurosurgical intervention are not entirely those of tumor extirpation, but are probably due to the decompressive effect and the adequate dealing with the lesion, so that reformation of the cyst is not possible and additional space for ultimate enlargement is granted the slow-growing process.

In the last analysis, the element of time enters into the problem in that medulloblastomas grow rapidly and thus disturb the cerebrospinal fluid circulation more profoundly. Shrinkage of the tissue by deep roentgen therapy and adequate decompression to permit functioning of the remaining cerebrospinal fluid pathways is the true answer to this problem, as admittedly the neurosurgeon is unable to fully extirpate the lesion or to assure himself that recurrence and extension will not proceed without the aid of deep roentgen therapy.

Although I have given up attempted extirpation of these tumors or even incisional disturbance of the tissue, nevertheless, I feel that the neurosurgeon has a most important part to play in maintaining the patient's intracranial pressure at favorable levels during the period required for deep roentgen therapy.

I believe the results obtained in the future will be in proportion to the sincere cooperation which exists between the roentgenologist and neurosurgeon in this distressing problem. Certainly the roentgenologist should not be given a patient unfit for proper irradiation, after an unsatisfactory neurosurgical attempt to remove the tumor tissue. I do not believe that the roentgenologist should attempt deep irradiation on these patients without helpful advice and preparedness by the neurosurgeon, in order to prevent acute stages that may arise in the course of treatment, relieving these stages by whatever means of control of increased intracranial pressure seem best adapted to the patient without feeling the necessity of exploring the tumor mass and jeopardizing both the neurosurgical and roentgen therapeutic results.

I appreciate the opportunity of discussing this most important presentation. I am sure that Dr. Chamberlain will agree that the favorable results in our small series are largely due to the excellent cooperation that has existed between the neurosurgical and roentgenological departments at Temple University.

I have held the conviction for the past eight years, that in cerebellar medulloblastomas, the most important part of this problem is that which the roentgenologist in the future will play. May Dr. Sosman continue to impress us with his favorable results.

DR. SOSMAN (closing). I want to thank Dr. Dyke and Dr. Fay for their very kind discussion. It is true that the main problem is one of controlling the intracranial pressure. Dr. Fay has outlined a good method of doing it, although somewhat radical. You can see the disagreement that exists. We advocate irradiation alone without operation. Dr. Fay advocates irradiation following decompression, but he fears to do a biopsy. Dr. Elsberg and Dr. Dyke advocate irradiation after decompression and biopsy. There is extreme disagreement all over the country with this fairly rare group of tumors and I think time alone will tell what the best procedure is.

As to the astrocytomas and the question of their radiosensitivity, I am sorry to say our results are practically negative. We have had very little improvement which we could be sure was due to the radiotherapy. Putting patients in the hospital, taking good care of them, getting them dehydrated, will result in a great many of them improving considerably. That could be explained by radiotherapy if it were given at the same time.

CHRONIC PNEUMONIA ASSOCIATED WITH NUTRITIONAL DISTURBANCES IN INFANTS

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IN THE past seven years we have observed nine infants, ranging in age from three weeks to seventeen months, who were brought for examination because of anorexia and failure to gain in weight. In almost every case adjustments of the diet had been made with no lasting beneficial effects. In each instance symptoms referable to the respiratory tract were either absent or not prominent; yet definite and marked pulmonary involvement was demonstrable in every case by roentgenologic examination. The abnormal shadows seen on roentgenologic examination were non-tuberculous in nature and were present for from four months to several years. These cases are reported for two reasons: first, to call attention to the fact that there occurs in infants a chronic, non-tuberculous type of pulmonary infiltration which is accompanied by nutritional disturbances; and second, to emphasize the importance and necessity of routine roentgenologic or roentgenoscopic examinations of malnourished infants whose nutritional requirements are adequately filled, both quantitatively and qualitatively. Without roentgenologic examination in several of these cases, the condition would not have been recognized.

CASE REPORTS

Case 1. C. B., a female, aged seventeen days, was brought for regulation of feeding and regular care on November 10, 1926. The birth history was normal and the child was breast fed. Physical examination was negative. The child thrived until August 1, 1927, when she was nine months old and was then brought for examination because she did not retain cereal or other solid food, but did retain milk. There was an occasional cough; the temperature was elevated to 100.2° F.; and the turgor was poor. Physical examination of the lungs revealed an area of bronchial breathing over the right upper lobe, posteriorly. Roentgenoscopy showed a shadow involving the right upper lobe. The Mantoux test was negative to 1 mg. of old tuberculin. A diagnosis of upper lobe pneumonia was made; the patient, however, did not present the severe manifestations commonly encountered in children suffering from an acute pneumonic process. The child was kept in bed until the temperature subsided, four to five days later. Apart from general hygienic measures and regulation of diet, no special treatment was instituted. The child was again examined on August 20; at this time she had gained eighteen ounces and the appetite had improved, but the shadow observed on August 1 was still present. She was seen again on September 6, when a loss of 3 ounces was noted; on November 28 physical signs, i.e., dullness and bronchial breathing, were still present, but the child had gained a pound in weight. The child was not seen again until May 8, 1928, six months later; at this time physical signs were still present and the roentgenoscopic examination revealed the presence of the same shadow. During this period she had lost 3 ounces in weight; the Mantoux test was again negative, this time to 2 mg. of old tuberculin. The child has been kept under observation until the present date and has been examined at varying intervals. She has always been below the average in weight and stature and she has never been as vigorous nor as active as a normal child. Following is a description of the roentgen studies made over a period of seven years:

Roentgen examination made on August 2, 1927, showed a generalized pneumonic consolidation involving the right upper lobe with exaggeration of the trunk markings radiating to the right base. There was a broadening of the superior mediastinum to the right, due either to secondary mediastinal adenopathy or possibly to an enlarged thymus. A study made sixteen months later showed some residual infiltration in the right upper lobe. Eighteen months later, on May 5, 1930, almost three years after the initial study, examination showed a diffuse patchy infiltration involving the lower two-thirds of the right upper lobe and an extension to the right lower lobe. A final study on July 1, 1934, almost four years later,

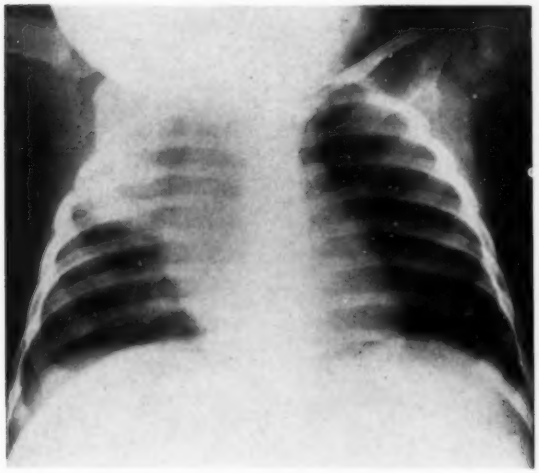

Fig. 1. Case 1. August 2, 1927. There is consolidation of the entire right upper lobe with a large packet of mediastinal glands on the right side.

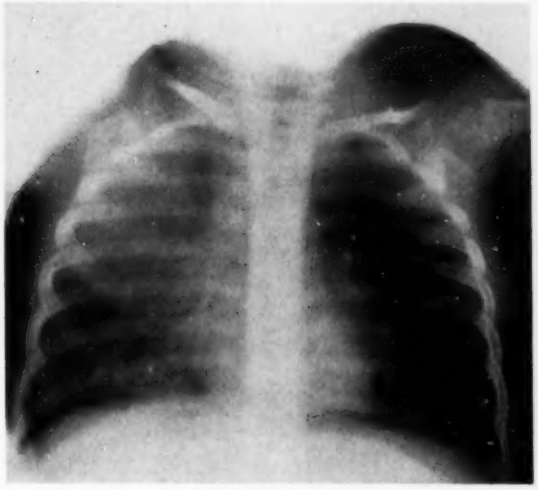

Fig. 2. Case 1. November 2, 1928. The infiltration of the right upper lobe is less homogeneous. There is evidence of resolution. The mediastinal adenopathy is less pronounced.

showed a residual fibrosis throughout the right upper and lower lobes (Figs. 1, 2, 3, and 4).

Case II. J. C., a male child, aged three weeks, was first seen on November 8, 1926, for regulation of feeding and general care. The birth history and the family history were negative. The child was placed on a cow's milk mixture with dextrimaltose and did well up to March 19, 1927, when he was brought for treatment at the age of four months because of elevation of temperature to 101° F., and anorexia. Cough was not present. Physical examination revealed poor turgor, but no abnormal lung signs. Roentgen examination showed an irregular coalescent area of infiltration involving the lower half of the right lobe (Fig. 5). The Mantoux test was negative to 1 mg. of old tuberculin. The temperature subsided in two days, but anorexia persisted. There were no changes in the child's condition until April 26, 1927, when physical examination revealed bronchial breathing and diminished resonance over the right upper lobe, posteriorly, approximately six weeks after the roentgen signs were first observed. During this period the child had gained approximately 1

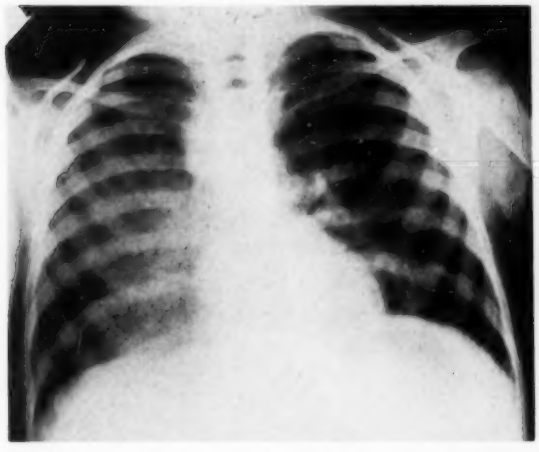

Fig. 3. Case 1. May 5, 1930. Diffuse patchy infiltration involving the lower two-thirds of the right upper lobe and an extension to the right lower lobe can be seen.

Fig. 4. Case 1. July 1, 1934. Diffuse interstitial fibrosis throughout the right upper and lower lobes is evident.

Fig. 5. Case II. March 19, 1927. There is a localized consolidation involving the lower half of the right upper lobe; infiltration is most pronounced in the mesial and basal portions.

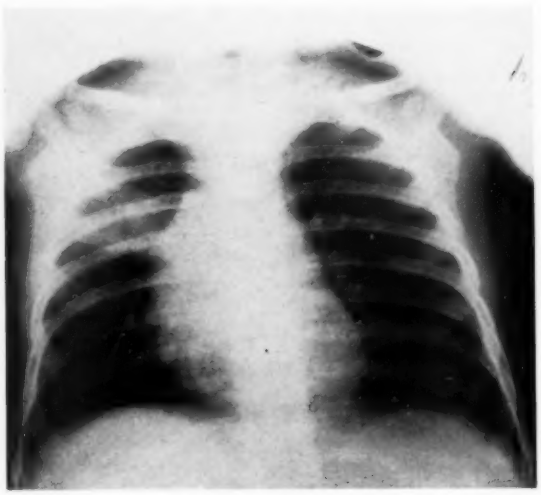

Fig. 6. Case II. August 13, 1927. No change from Figure 5 can be noticed.

pound. On May 7, 1927, the child developed an intermittent fever ranging from 100 to 101° F. and which persisted until June 11, 1927. Physical and roentgenoscopic findings were unchanged during this period. When the child was again seen on August 13, 1927, at the age of ten months, there was no change in the findings (Fig. 6). On October 2, 1927, the child developed a fever fluctuating between 101 and 102° F., which persisted for approximately two and a half months; there was still no change in the physical or roentgen findings. The Mantoux test was repeated and found to be negative to 2 mg. of old tuberculin. During this period the child gained slowly. On February 23, 1928, there was first observed a change in the physical signs, i.e., râles were heard at the right base, posteriorly; roentgen examination showed almost complete resolution of the exudate with some evidence of residual patchy infiltration (Fig. 7). From this time on until last observed on June 15, 1934, the child made slow gains, always remaining, however, below the average weight. A final roentgen study made on July 1, 1934, revealed the lung field to be clear. There

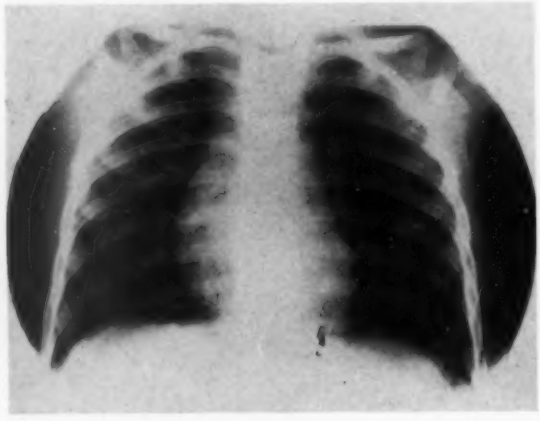

Fig. 7. Case II. February 23, 1928. A slight irregular patchy type of infiltration can still be seen in the right upper lobe. The exudate has resolved to a great extent.

Fig. 8. Case II. July 1, 1934. Bilateral exaggeration of both root and trunk markings is seen; both lung fields are clear.

was some exaggeration of the root shadows on both sides but not sufficient to be considered abnormal (Fig. 8).

Case III. P. H., a female white child, aged seventeen months, was first seen on November 9, 1933, because of anorexia, failure to gain in weight, inability to walk or stand, and restlessness. The past history was negative. The diet had been quantitatively and qualitatively adequate, but at the age of four months the infant had begun to refuse food and forced feeding was resorted to. The mother was carefully questioned as to the presence of cough, fever, or dyspnea at any time before this examination. She stated positively that these symptoms were not observed at any time. Physical examination revealed a dystrophic child with poor skin turgor, unable to stand. Physical examination of the lungs revealed impaired resonance on the right side, posteriorly. Roentgen examination showed a patchy irregular infiltration of the right upper and the right lower lobes. The interlobar pleura was thickened and clearly demarcated the three lobes. There was an enlargement of the mediastinal glands on the right side (Fig. 9). The temperature was normal; the Mantoux test was negative to 1 mg. of old tuberculin. Physical and roentgenoscopic examinations of the lungs on November 25 gave the same results as the previous examination.The infant was again seen on December 2 when the mother said that the child ate poorly and had

Fig. 9. Case III. November 10, 1933. Diffuse patchy infiltration throughout the right lung, most pronounced in the upper and lower lobes, is noticed. Thickening of the interlobar pleura demarcating the three lobes is noticed.

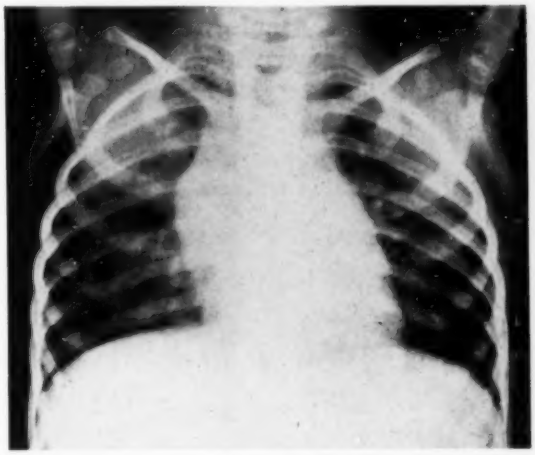

Fig. 10. Case III. May 29, 1934. The infiltration is more homogeneous in the peripheral portion of the right upper lobe; there is slight resolution of the exudate in the lower lobe. The enlargement of the mediastinal gland is more pronounced.

gained very little weight since the first visit. Roentgenoscopic examination showed the same shadows that were previously noted. The parents decided to take the child to Florida where she was kept in the sun and fresh air almost constantly. On May 29, 1934, six months later, the child was again brought for examination; she had gained $4\frac{1}{4}$ pounds; her appetite had markedly improved; her color was good; and she walked without difficulty and firmly, whereas previously she had been too weak to walk at all. The turgor and muscle tone were also definitely improved. Physical examination of the lungs was negative; but roentgen examination showed the infiltration to be more homogeneous in the peripheral portion of the upper lobe; slight resolution of the exudate in the lower lobe was also evident. The mediastinal adenopathy was more pronounced (Fig. 10). The child is still under observation.

Case IV. B. L., a white male infant, aged three weeks, was first seen on February 3, 1928, because of vomiting, restlessness, and loss of weight; the vomiting began when the infant was ten days old and at times it was projectile in character. Past history, birth history, and family history were negative. There was no history of cough or respiratory difficulty. Physical examination was completely negative. Roentgen examination, however, showed a marked broadening of the superior mediastinum on the right side, sharply demarcated laterally, due

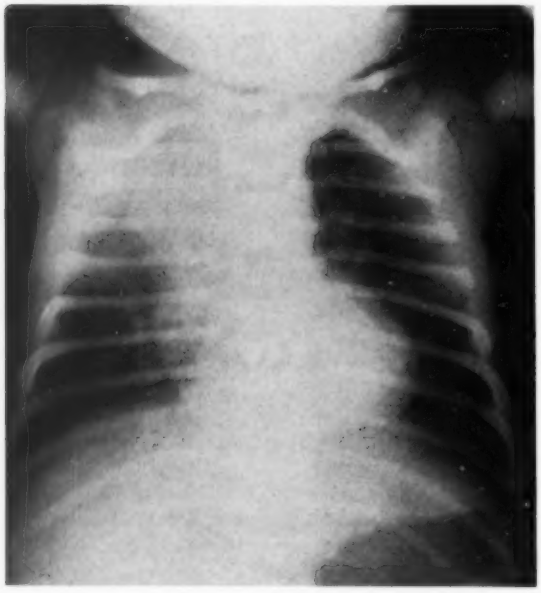

Fig. 11. Case iv. February 3, 1928. There is a marked broadening of the superior mediastinum to the right; the adjacent lung shows diminished aeration.

possibly to an enlarged thymus. The adjacent lung showed diminished aeration due either to compression atelectasis or to infiltration (Fig. 11). The infant was given thick cereal feedings prepared with one-half milk, and the mother was told to return with the child in one month. The infant was not seen again, however, until April 13, when he was three and one-half months old; he was brought at this time because of anorexia and failure to gain in weight; the vomiting, however, had disappeared. Examination showed an infant with poor turgor, a congenital stridor, and an eczema of the face. Physical examination of the lungs was still negative, but marked retraction of the xiphoid and lower portion of the chest wall was now observed. Roentgenoscopic examination revealed a shadow in the right upper lobe. When again seen on June 2, 1928, there were physical signs present—diminished resonance and bronchial breathing over the right upper lobe, posteriorly. (Physical signs were possibly present at the previous examination, but may have been missed; the frequency with which physical signs were elicited after roentgenoscopic examination had revealed a shadow is probably due to the fact that more attention and greater care were observed in the subsequent examinations. It is possible, of course, that physical signs are not present in the early stages of this type of lesion.) On June 14, the temperature was elevated to 102° F., but there was no dyspnea nor increased respiratory rate. Roentgen examination showed a generalized diminution of aeration of the right upper lobe, apparently due to a diffuse pneumonic infiltration. The mediastinal shadow was diminished in size (Fig. 12). The Mantoux test done at this time showed no

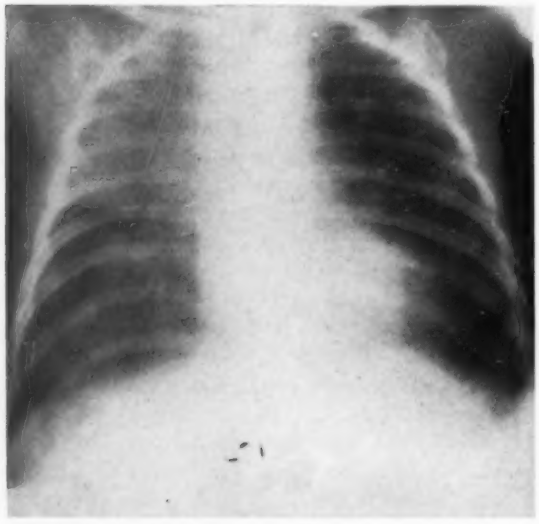

Fig. 12. Case iv, June 14, 1928. There is diffuse infiltration of the right upper lobe, the mediastinal shadow has diminished in size.

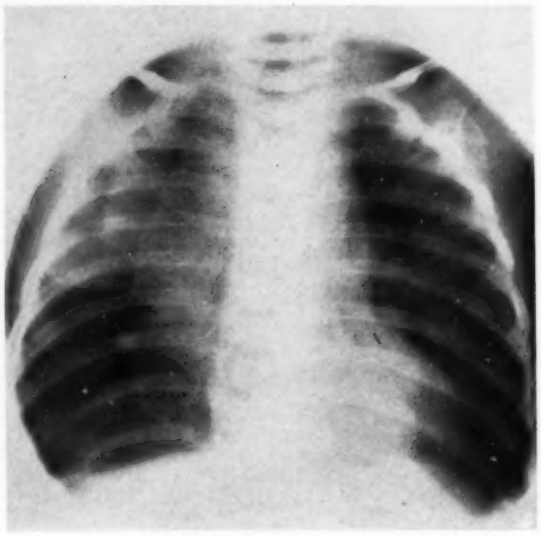

Fig. 13. Case iv. September 20, 1928. Beginning resolution of the infiltration in the right upper lobe is present.

reaction to 1 mg. of old tuberculin. When next seen, on July 30, the infant's appetite was still poor, the gain had been slow, and the appearance of the lung shadow was the same; a severe cough was now present for the first time. During the next month and a half, i.e., until September 20, the child gained 1 pound, although the appetite was still poor, and the cough was present and violent in character. On this date physical examination of the lungs revealed moist râles at the right base, posteriorly, and paravertebral dullness on the right side. Roentgen examination showed that the infiltration appeared to be resolving with irregular areas of aerated lung present throughout the upper lobe. The mediastinal shadow persisted (Fig. 13). During the next two months, to November 13, the appetite improved, and the child gained 2 pounds. Physical examination revealed only diminished breath sounds over the right upper lobe, posteriorly. When last seen on May 17, 1930, the infant was two years and four months of age and weighed 26 pounds and 9 ounces. Anorexia and cough were still prominent symptoms, but there was no elevation of temperature. Physical examination revealed diminished breathing and resonance on the right side, posteriorly; roentgenoscopy showed a less intense shadow.

Case v. J. K., a white female, aged seven weeks, was first seen on January 29, 1934, because of anorexia and failure to make adequate gain in weight. The birth weight was 6 pounds and 11 ounces. The child had been given complementary feedings of a one-half milk and water mixture immediately after birth, but these were discontinued after two to three days when the breast milk had sufficiently increased in amount to satisfy the infant's requirements. When the child was sixteen days old, a milk and water mixture with the addition of cane sugar was again prescribed; the infant took the bottle readily but vomited shortly after and became violently ill; the vomiting was profuse and almost incessant. The mother also said that the child became pale and perspired a great deal. Since then the infant refused all bottle feedings and took the breast poorly; the gains in weight were only from 2 to 3 ounces a week. The child had received a daily dose of ten drops of viosterol since five weeks of age. There was no history of a running nose, but the cough was persistent since the vomiting episode. Physical examination revealed a fairly well-nourished infant with fair turgor; the weight was 8 pounds and 9 ounces; there was a definite pallor. Physical examination of the lungs was negative; but roentgen examination revealed a diffuse irregular infiltration of the right upper lobe, more marked mesially with prominent root and peribronchial infiltration on this side. The left side showed a diffuse coalescent infiltration involving the middle two-thirds of the lung field (Fig. 14). The hemoglobin (Sahli) was 70 per cent. The infant was seen at various intervals until June 26. On that day a Mantoux test with 0.1 mg. of old tuber-

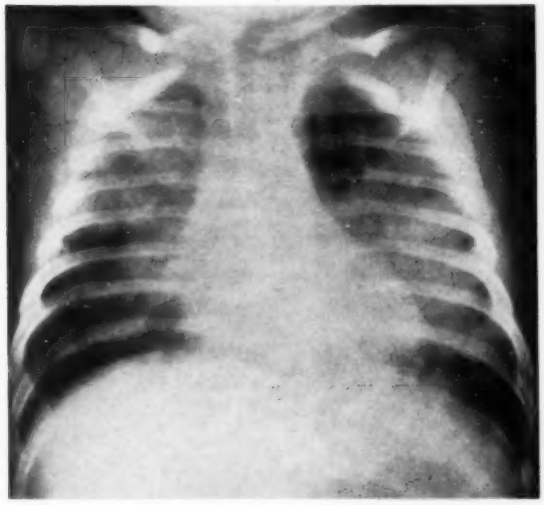

Fig. 14. Case v. January 29, 1934. Diffuse irregular infiltration of the right upper lobe with a coalescent infiltration involving the middle two-thirds of the left lung can be seen.

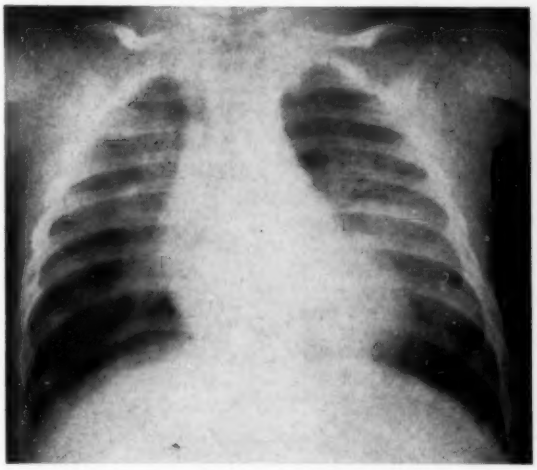

Fig. 15. Case v. June 26, 1934. No appreciable change can be seen.

Fig. 16. Case vi. March 10, 1934. A diffuse patchy type of infiltration throughout the right upper lobe is present, bilateral root and trunk markings and broad mediastinal shadow can also be seen.

culin was negative. During this five months' period the child gained 8 pounds, the appetite improved moderately, restlessness disappeared somewhat, and the pallor disappeared. The cough persisted until April 1, 1934, about thirteen weeks after it had first been noticed, and on June 26 there was no cough at all. No definite physical signs of a pulmonary lesion could be elicited at any time during this period of observation. The pulmonary shadows persisted, however, and were still present at the last examination (Fig. 15). The temperature was normal when the infant was first seen and remained normal during the entire period of observation.

Case vi. H. S., a white male infant, aged three months, was first seen on March 10, 1934, because of vomiting of three days' duration, anorexia, and marked restlessness; indeed, the mother stated that for the past two months the baby had been screaming almost continuously; the anorexia was of one month's duration. The gains in weight had been normal, approximately 8 ounces a week, until one month ago; since then the gains were irregular, averaging 2 to 3 ounces a week. Delivery was normal, birth weight being 6 pounds and 4 ounces, and the infant was breast fed exclusively until February 15 when complementary feedings were prescribed; the mother, however, experienced difficulty in getting the child to take the bottle, and forced the infant to take food. Haliver oil and viosterol in fifteen drop doses had been given for the past eight weeks. There was no history of a respiratory infection; the mother was positive that at no time had there been any cough or elevation of temperature. Physical examination (only essential findings are given): The weight was 11 pounds; the turgor was poor; the temperature was normal; the liver was palpable one-half finger's breadth and the spleen, two fingers' breadth below the costal margin. Examination of the heart and lungs was normal. Roentgen examination, however, revealed a diffuse infiltration of the right upper lobe with prominent root and trunk infiltration on both sides. There was a broad mediastinal shadow present suggestive of an enlarged thymus (Fig. 16). The child was examined several times during the next four months. At no time was there any elevation of temperature nor any cough. A Mantoux test with 1 mg. of old tuberculin was negative. The appetite gradually improved, regular gains in weight were noted, and at six months of age the infant weighed 15 pounds and 6 ounces. Definite signs of a pulmonary lesion were not found at any time. The pulmonary shadows remained unchanged and were still present on September 26, seven months after they were first detected (Fig. 17).

Case vii. E. S., a white female, aged four weeks, was first seen at home on March 15, 1934, because of anorexia, vomiting, and failure to make sufficient gains in weight. The mother said that the infant had developed a cough within the past three days and that there was an elevation of temperature for the last two

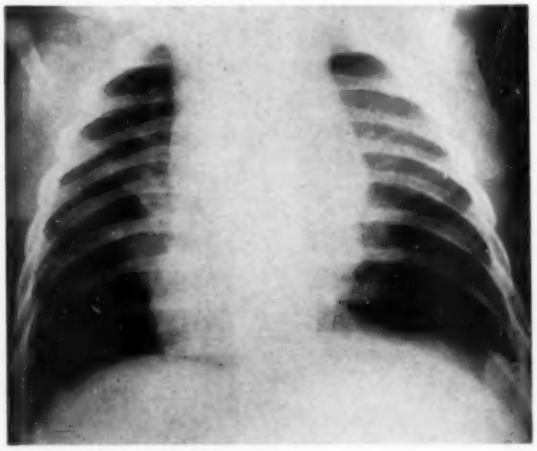

Fig. 17. Case vi. September 26, 1934. No change since the previous examination can be seen.

days. The delivery was normal and the birth weight was 6 pounds and 2 ounces. Almost immediately after birth the infant was given complementary feedings of a one-half milk and water mixture with the addition of 6 per cent sugar. Subsequently, the infant refused the breast entirely and a cow's milk mixture of three-fourths milk and 7 per cent sugar was given. The artificial feedings, however, were not taken any more readily than the breast and the mother resorted to forced feeding. There is no definite history that the child choked on any of its feedings. This was the second child; the first had died at five days of age because of an esophageal atresia. Both parents were well and there was no history of

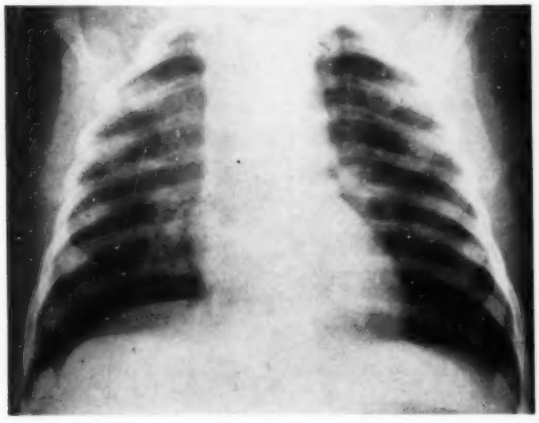

Fig. 18. Case vii. May 3, 1934. Infiltration of the right upper lobe, most pronounced mesially, and a similar lesion, less marked, in the left upper lobe, can be seen.

tuberculosis. Physical examination showed a pale infant with poor turgor but good muscle tone; the respiratory rate was increased and the breathing was somewhat labored; slight cyanosis of the lips was present. The abdomen was markedly distended; the temperature was elevated to 101° F. Examination of the lungs showed an area of impaired resonance and bronchial breathing over the right upper lobe, posteriorly. Aside from the presence of a nasopharyngitis, the remainder of the examination revealed nothing of interest. The child remained at home under the care of the family physician and was not seen again until six weeks later, on May 3, when the infant was ten weeks old. At this time the mother still complained that the child did not take its feedings well, that it vomited, and that it did not gain. Cough was still present. Examination showed

Fig. 19. Case vii. July 15, 1934. There is a slight spread of the lesion on the right side.

a marked pallor and the presence of a slight eczematous eruption on both cheeks. Physical signs of an infiltration of the right upper lobe were still present. Roentgen examination showed a coalescent pneumonic infiltration of the right upper lobe with a similar lesion, less marked, in the left upper lobe (Fig. 18). The hemoglobin (Sahli) was 60 per cent, and 30 grains of saccharated iron carbonate a day was prescribed. The cough and pallor persisted until about the middle of July; the roentgen examination at this time showed a slight spread of the lesion in the right side (Fig. 19). On September 7, roentgen examination still showed a shadow in the right upper lobe (Fig. 20). The gains in weight during this period of observation (March 15 to September 15) were at all times inadequate, and the appetite was never good. From time to time during this period

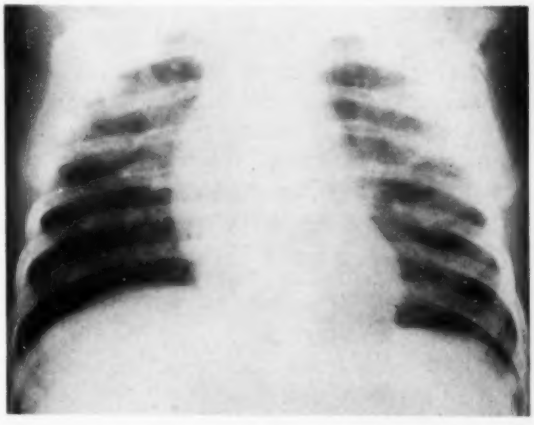

Fig. 20. Case vii. September 7, 1934. No appreciable change can be seen.

elevations of temperature to 102° F. occurred without the presence of any additional signs or symptoms; these febrile periods would last five to six days at a time. On May 3, 1934, a Mantoux test with 1 mg. of old tuberculin was negative. On January 15, 1935, the Mantoux test was repeated with 5 mg. of old tuberculin and was again found to be negative. The child is still under observation.

Case VIII. A. U., a white male infant, aged three months, was first seen on December 2, 1929, because of vomiting, anorexia, and loss of weight. Physical examination revealed marked pallor, bilateral eczema of the cheeks, an elevation of the temperature to 101° F., and the presence of a nasopharyngitis and a left otitis media. The mother had been instilling albolene into the nose of the infant. Physical examination of the lungs was negative. On December 5 the child was again seen and examination showed a subsidence of the upper respiratory infection; the appetite had improved, and the temperature was normal. On December 12 the child was again brought for examination because of a recurrence of the anorexia and a failure to gain in weight. At this time the temperature was normal and had been normal during the entire week. Physical examination of the lungs was negative, but roentgenoscopy revealed a shadow in the right upper lobe and a shadow adjacent to the left cardiac border. Two days later the child developed a severe cough without any rise in temperature. The Mantoux test was negative to 1 mg. of old tuberculin. Physical examination of the lungs revealed impaired resonance on percussion over the right upper lobe, and the bronchial breathing over the left side, posteriorly; roentgenoscopy showed no changes from the previous examination. The infant did not look ill, was not dyspneic, and there was no increase in the respiratory rate. On December 24 physical examination of the lungs showed a few râles over the right upper lobe and in the left interscapular space; the percussion note was still impaired and roentgenoscopy showed the same shadows previously noted. The child was again seen three and one-half months later, on March 5. In the interval there had been a gain of 3 pounds in weight and the appetite had improved; the temperature had not been elevated at any time; no cough, no dyspnea, and no increased respiratory rate had been noticed. Physical examination of the lungs revealed impaired resonance and diminished breath sounds over the right upper lobe, posteriorly; roentgenoscopic examination showed a less intense shadow on the right side. The child was last seen on March 21, 1930, at which time roentgenoscopic and physical examinations of the lungs were negative.

Case IX. H. T., a white male infant, aged two months, was first brought for examination on December 14, 1933, because of anorexia and failure to gain in weight. Delivery was normal, the birth weight being 6 pounds and 5 ounces; the infant was breast fed exclusively for one week and was then given complementary feedings of a one-third milk and water mixture with the addition of 5 per cent sugar. The mother said that the infant took from 1 to 1½ ounces of this mixture after each breast feeding, but that it refused orange juice. Viosterol in 10 minim doses was given once a day. At times projectile vomiting occurred and the infant forcibly expelled gastric contents through the nose as well as through the mouth. Vomiting was present since the additional feedings were given. Slight cough had also been noticed for the past three weeks. Physical examination showed a dystrophic infant with poor turgor and a body weight of 8 pounds and 6 ounces; the spleen and liver could be felt one-half finger's breadth below the rib; the heart and lungs were normal. Roentgenoscopic examination was also negative. The infant was seen again one week later; at this time cough was still present, pallor was noticed, and a determination of the hemoglobin (Sahli) was 60 per cent; saccharated iron carbonate in 30 grain doses, daily, was prescribed. On January 11 the mother reported that the cough had increased, and that the appetite had not improved. Examination of the lungs was negative but roentgenoscopy revealed for the first time a shadow in the right upper lobe. The shadow in the right lung field could be seen at various examinations for several weeks, becoming less intense as time went on; and on March 8, 1934, it was no longer visible. Throughout this period the temperature remained normal and the appetite poor. On February 12 the mother stated that the cough had disappeared for a time but that it had returned again a few days before the examination. From this time on gradual improvement took place: the appetite improved, gains in weight occurred, although the infant never attained the average normal weight—in

fact, on June 18, when it was eight months old, the weight was only 13 pounds and 5 ounces. Physical and roentgenoscopic examinations at this time were entirely negative. The Mantoux test with 1 mg. of old tuberculin was negative.

DISCUSSION

It was impossible to determine definitely the time of onset of the disease in all cases, but symptoms were present as early as two and one-half weeks of age. In all but 2 infants (Cases I and II) the onset occurred before five months of age: in one child (Case III) it was impossible to come to any conclusion as to the probable time of onset. It seems, however, that this type of pulmonary involvement begins in early infancy. In 3 infants physical signs could be detected only after a period varying from two to ten weeks, after the first examination (Cases II, IV, VIII); in 3 children (Cases I, III, VII) physical signs were obtained at the first examination, and in 3 infants (Cases V, VI, IX) physical signs could not be elicited at any time during the period of our observation. Thus, in 3 infants physical signs were first elicited after the roentgen study demonstrated the presence of a lesion. This may be explained either by the fact that there were actually no physical signs when the child was first seen and that these signs developed later, or that added care and attention were given to physical examination of the lungs after it was determined by roentgen examination that a lesion was present. It is our belief that the latter explanation is the correct one. The physical signs, when present (6 cases), were those of pulmonary consolidation, namely, dullness or impaired resonance and low pitched bronchial breathing; in only 2 children (Cases II and IV) were râles heard. These were heard only once and could not be elicited at subsequent examinations.

Anorexia and failure to gain in weight, or inadequate gains in weight, were present in every case. With the exception of 2 infants who were under routine care, all these children were brought to us solely because of these complaints. The anorexia was almost complete in 5 of the children and moderately severe in 3. While all 9 infants failed to gain adequately, only 2 lost weight. None of the infants became atrophic, although 4 children developed a definite dystrophy. Cough was present in 6 infants; rapid respiration and dyspnea were present in only one infant (Case IV); as mentioned before, respiratory symptoms were not prominent. In fact, in 7 infants, although they were under regular medical supervision, the presence of a pulmonary lesion was never suspected. In the other 8 children respirations were easy and were not increased above the normal rate. Vomiting was present in 7 of the 9 infants. Irritability and excessive perspiration were observed in 5 children. The chief complaint in one of the infants (Case III), who was seventeen months old when first seen, was inability to stand or walk. In 3 infants there was no elevation of temperature; 6 children had fever from time to time, but in no child was the temperature elevated above 102° F. Symptoms were present for periods ranging from six weeks to twenty-eight months after the recognition of the lesion. All 9 children reacted negatively to repeated intracutaneous injections of old tuberculin, given in doses of 0.1 to 2 mg. The tuberculin used was supplied by the New York City Board of Health; the dilutions were freshly prepared immediately before use. We are certain that the tuberculin was potent because positive reactions were obtained in other children (not included in this series) suffering from tuberculosis.

ROENTGEN FINDINGS

The roentgen findings varied greatly as to the extent and character of involvement. The right side was involved in every instance, particularly the right upper lobe which showed the most extensive changes. The right lower lobe was next in frequency. In 2 instances (Cases V and VII) bilateral lesions were seen. The character of the pulmonary infiltration was either a homogeneous consolidation involving all or part

ANALYSIS OF CASES

Name	Age at Onset of Symptoms	Age at Onset of Pulmonary Physical Signs	Age at which Roentgen Changes Were Found	Symptoms	Physical Findings in Lungs	Temperature	Roentgen Findings	Duration of Symptoms	Duration of Physical Findings	Duration of Roentgen Findings	Remarks
C.B. Case I	9 mo.	9 mo.	9 mo.	Anorexia; vomiting; cough; irritability; excessive perspiration	Bronchial breathing and dullness over right upper lobe posteriorly	100.2° F. at onset for 4–5 days	Homogeneous shadow involving entire right upper lobe	18 mo.	18 mo.	4 yr.	Feedings forced by mother
J.C. Case II	4 mo.	5½ mo.	4 mo.	Anorexia (no cough)	Six weeks after onset of illness: bronchial breathing and diminished resonance over right upper lobe posteriorly; râles at right base after 9½ mo. of illness	101° F. at onset for 2 days. Had 2 bouts of fever in 28 mo.; one lasted two wk. and one, one week	Homogeneous shadow involving lower half of right upper lobe	28 mo.	28 mo.	11 mo.	
P.H. Case III	?	17½ mo.	17½ mo.	Anorexia; excessive perspiration; restlessness; failure to gain; inability to walk or stand	Dullness and bronchial breathing on right side posteriorly	Temperature up to 101° F. for 2 weeks when first seen	Shadow in right upper and right lower lobes	Less than 6 mo.	Less than 6 mo.	Still present after 6 mo. of observation	Forced feedings
B.L. Case IV	3½ mo.	5½ mo.	5 mo.	Dyspnea; anorexia; failure to gain; irritability; vomiting; cough	3 mo. after onset: dullness and bronchial breathing over right upper lobe; râles at right base after 3 mo. illness	Temperature normal at onset; 102° F. at 6 mo.	Shadow in right upper lobe	Still present after 2 yr.	Still present after 2 yr.	Still present after 27 mo. of observation	
J.K. Case V	2½ wk.	No physical signs	7 wk.	Anorexia; irritability; excessive perspiration; loss of weight; persistent cough; profuse vomiting	No pulmonary findings	Normal temperature	Shadow in middle two-thirds of left lung and mottled infiltration over entire right upper lobe	1½ mo.	No pulmonary findings	Still present after 6 mo. of observation	
H.S. Case VI	1 mo.	No physical signs	3 mo.	Vomiting; anorexia; restlessness; failure to gain	No physical findings	Normal temperature	Diffuse irregular shadow throughout right and left upper lobes	2 mo.	No physical signs	Still present after 7 mo. of observation	Forced feedings; no history of respiratory infections
E.S. Case VII	4 wk.	4 wk.	10 wk.	Anorexia; cough; vomiting; excessive perspiration; failure to gain	Dullness and bronchial breathing over right upper lobe posteriorly	Fever for one week at onset and at age of 5 mo.	Shadow in right upper lobe	Still present after 4 mo.	4 mo.	Still present after 4 mo. of observation	Forced feedings
A.V. Case VIII	3 mo.	3½ mo.	2 days before physical signs (3½ mo.)	Anorexia; vomiting; loss of weight; cough	Twelve days after onset: dullness and bronchial breathing over left upper lobe	101° F. at onset for 4 days	Shadow in right upper lobe and also adjacent to left cardiac border	3½ mo.	3 mo.	3½ mo.	Mineral oil given at age of 2½ mo.
H.T. Case IX	2 mo.	No physical signs	2½ mo.	Anorexia; failure to gain; vomiting; cough	No physical findings	Normal temperature	Shadow in right upper lobe	3 mo.	No physical signs	2 mo.	Forced feedings; no history of respiratory infections

of a lobe or a diffuse patchy coalescent lesion similar to that seen in bronchopneumonic infiltration. The infiltration in several instances persisted for several years and in one child (Case I) the lesion was present for four years before resolution occurred. During this interval there was a spread from the right upper to the right lower lobe. In this patient follow-up studies four years later revealed a residual generalized interstitial fibrosis throughout both lungs. In Case II the infiltration persisted for a period of eleven months, following which the lung field cleared completely, leaving no residual involvement aside from a slight root adenopathy. Case IV was followed for a period of twenty-seven months. During this interval there was gradual lessening in the extent of infiltration which, however, was still present at the last examination. Four other cases (Cases VI, III, V, and VII) followed with repeated roentgen studies for seven, six, six, and four months, respectively, showed little or no change in either the extent or character of the lesion. Cases VIII and IX, followed roentgenoscopically for periods of three and one-half and two months, showed complete resolution of the exudate.

In addition to the parenchymal infiltration, secondary changes such as mediastinal adenopathy, chronic root infiltration, bronchial dilatation, and peribronchial thickening were frequently present. Several cases showed the presence of an enlarged thymus. We believe that this finding was incidental and was not responsible for any of the changes observed. No evidence of compression or displacement of the trachea was noted. One patient (Case IV) showed what appeared to be compression atelectasis of the right upper lobe, due to an enlarged thymus, but later studies showed the lesion to be an infiltration rather than atelectasis.

From a roentgenologic point of view these lesions are not tuberculous in nature. This was shown clinically also by the persistently negative cutaneous tests. Repeated roentgenologic examinations of these patients were made over a prolonged period of time and in no instance was there any evidence of calcification of the paratracheal, tracheobronchial, or bronchopulmonary glands, nor was there ever evidence of cavitation or other findings characteristic of tuberculosis. Atelectasis was ruled out by the absence of the characteristic roentgen findings, namely, airless state of the lung, retraction of the lung field, drawing over of the mediastinum to the involved side, narrowing of the costal spaces, and elevation of the diaphragm. Chronic root adenopathy, as well as findings characteristic of bronchitis and bronchiectasis, was present in several instances, but these were secondary to the parenchymal pathology and not the primary lesion.

COMMENT

Because of the uncertainties and difficulties that go hand in hand with an attempt to determine the character and etiology of chronic pulmonary infiltrations from a clinical and roentgenologic point of view alone, it is possible to state definitely only that these lesions are due neither to a tuberculous infection nor to atelectasis. Careful physical and roentgenologic examinations failed to reveal the presence of congenital syphilis in any of these children. In addition, the mode of onset, the symptomatology, the roentgenologic findings, and the clinical course do not fit in with any of the ordinary types of pneumonia encountered by the practising physician. Whether the infiltration in the lungs in some of these children was the result of aspiration of fatty or oily substances producing lipoid pneumonia, it is impossible to say (Laughlen,[1] Pinkerton,[2] Pierson,[3,4] Rabinovitch and Lederer,[5] and Goodwin[6]). Lipoid pneumonia is sometimes the cause of chronic non-tuberculous lung infiltrations, but unfortunately there is no known clinical method of determining the presence of fat in the lungs. Repeated sputum examinations for the presence of fat were consistently negative in Goodwin's pa-

tients. Lung puncture might be tried, but whether consistent and sufficient information could be obtained to justify its use is questionable.

We wish therefore merely to emphasize the fact that a type of lung infiltration is encountered in infants and very young children which runs a chronic benign course and which is always associated with definite disturbances of nutrition. In every child under our observation anorexia and failure to gain were the chief complaints; in several infants they were the only complaints. Whether the vomiting and anorexia which is usually associated with a poor nutritional status is directly or indirectly responsible for the pulmonary changes or whether the pulmonary changes produce the bad nutritional status, it is impossible to state at this time. The anorexia and the failure to gain in weight are the two outstanding complaints that bring the child to the attention of the physician and are, we believe, the most characteristic clinical features of this type of infiltration. The respiratory rate is not accelerated, as a rule, and cough is not an outstanding symptom; in fact, it may be said that symptoms referable to the respiratory tract are practically absent. Physical signs may be obtained in some cases but in others they may be completely absent; even when elicited, physical signs give no other information than that some sort of pulmonary consolidation is present. Actual dullness is rarely present but impaired resonance is found, as a rule; the breath sounds are bronchial in quality and usually diminished, and râles are rarely heard. Cyanosis is not an outstanding symptom. A history of an acute pulmonary disturbance is not obtained; careful questioning of the mothers of our patients failed to reveal such a history in any case. If no associated infectious process is present, this type of pulmonary infiltration is not accompanied by an elevation of body temperature, as a rule.

Roentgenographic studies offer the greatest help in the recognition of this disease. In our patients roentgenologic examination always indicated more extensive pulmonary involvement than was found on physical examination. Most characteristic was the persistence of the shadows over a long period of time. In this series the shadows were present in every case for at least three months and in one case for four years. The importance of routine roentgenologic or roentgenoscopic examination in malnourished infants and very young children is therefore obvious.

PROGNOSIS

No deaths occurred in this series. From the point of view of prognosis, it is particularly important to recognize that a benign type of pulmonary infiltration exists and that this condition is not to be confused with tuberculosis. Months and, at times, years, however, may elapse before a diminution or disappearance of the roentgenologic shadows takes place.

No particular method of treatment was followed; healing of the involved lung lesion, as determined by the disappearance of the shadow on roentgenologic studies, was entirely spontaneous. All the infants were given adequate feedings and frequent changes in formula were avoided, even if gains in weight did not immediately set in. For want of a better method of treatment, a policy of patient waiting was pursued, a policy acceptable to the parents, since from our experience we could assure them that eventually healing would set in and that simultaneously with it an improvement in the nutritional status would take place.

SUMMARY

1. During the past seven years we have observed in private practice nine infants who had marked anorexia and who did not gain in weight, yet every infant had a chronic non-tuberculous pulmonary lesion. These children were observed for from three months to seven years.

2. Roentgenologic studies showed involvement of the right upper lobe in every

instance; in some infants the lower lobes and the left side were also involved.

3. Physical signs were not always present and, when present, in some of the infants there were few signs or symptoms referable to the respiratory tract.

4. Roentgenologic changes and clinical signs and symptoms were present for periods varying from a few months to several years.

5. The course was benign in every instance; no deaths occurred.

6. The etiology is obscure; the possibility that these lung changes are due to the aspiration of oils or fatty substances is discussed.

7. Finally, we wish to emphasize the fact that anorexia and failure to gain in weight in an infant or stunting of growth in very young children should not be attributed merely to a nutritional disturbance or to bad feeding habits; a careful search should be made for the possible existence of a pulmonary lesions even in the absence of respiratory symptoms and physical signs.

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CONCERNING SOME PATHOPHYSIOLOGICAL PECULIARITIES OF THE FUNCTION OF THE VERTEBRAL COLUMN

MECHANISM OF FRACTURES OF THE TRANSVERSE PROCESSES OF THE LUMBAR VERTEBRAE

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AT THE present time fractures of the transverse processes of the lumbar vertebrae are diagnosed rather frequently, though from the statistics of older authors we see that formerly such fractures were diagnosed much more rarely. This circumstance can apparently be explained by improved diagnosis by the use of the roentgen ray. In his paper, in 1910, Tanton gives statistics of 19 cases which he had collected up to 1907. In most cases the fractures of the processes were on the right side, and rarely on both sides. Wiart has published 60 cases of fractures of the transverse processes. Helf and Solcard have published 64 cases in their article and Davis of Chicago, 10 cases. These authors note that unilateral fractures occur in about 40 per cent of the total number of fractures of the transverse processes of the lumbar vertebrae. Vishnevski, of Tomsk, in 1929 gave a description of a fracture of a transverse process of the third lumbar vertebra with a displacement of the fragment with the tip turned down. The same author has described a fracture of the processes of the first to the fourth vertebrae of the right lumbar section as a result of a severe trauma suffered in a fall from a building. The patient had severe hematuria and consecutive pathologic complications which for a long time prevented his walking.

In all the above cases there was a fracture of the processes as a result of either direct trauma or a so-called indirect trauma, as, for instance, the falling from a great height.

In our cases it is noteworthy that there were no indications of the patients having had a recent trauma or any mechanical injury to the lumbar region, or even a fall; however, a detailed examination finally disclosed isolated fractures of the transverse processes unilaterally.

The conditions of labor and profession also cannot in our cases be the reason or occasion for so-called unnoticed habitual traumas which may frequently be the cause of fractures in persons who perform unusual labor, or in persons performing heavy physical work. Our cases concern individuals who are in their prime and are physically well developed. Their conditions of labor and their occupations cannot be the cause of fractures of the transverse processes (men in the military service). This circumstance induces us to turn our attention to the cases of fractures without a so-called direct trauma.

In the anamnesis of such patients there are generally no indications of any trauma. They are often continuously treated at the dispensaries for lumbago or neuralgia and only occasionally are they referred to the roentgen department, where the real cause of their complaint is discovered.

In this article we are not interested in cases of fractures of the transverse processes in which there are other severe traumatic lesions, as, for example, those after a fall from a height or when falling pieces of rock in a mine inflict such lesions, etc. In such cases severe alterations are prominent, such as fractures of the vertebrae with compression, derangements of the defecatory and urinary functions, hematuria, lacerations of the skin, etc. In such

cases the state of the transverse processes is of no interest to us. The isolated fractures of the transverse processes, occurring without a direct traumatic insult are of interest from the point of view of pathologic anatomy and of clinical diagnosis, and especially so from the point of view of the mechanics of the fracture itself. Our cases are especially illustrative inasmuch as these patients had frequently applied for surgical and neurologic help while the real reason was only casually ascertained. The following is a short description of our cases:

CASE REPORTS

Case 1. A sportsman, proficient in riding, was referred by his surgeon for a roentgen examination of the lumbar region of the spine. There had been pain in this region for about six months. Physiotherapy had been of no avail. The patient is well developed; there are no physical defects. Gastrointestinal and genitourinary systems are normal. He has no recollection of any trauma to the lumbar region or of any fall. Flexion and extension of the spine are not limited but slightly painful. Palpation is painful in the right lumbar region at the level of second and third lumbar vertebrae. Rotation to the left increases the pain. The roentgenogram (Fig. 1) shows a fracture of the right third transverse process with a slight displacement of the latter longitudinally (without rotation).

Fig. 1. (Film 2684) Case 1. Fracture of the right transverse process of third lumbar vertebra with slight displacement longitudinally.

Fig. 2. (Film 2635) Case 11. Fracture of the right transverse processes of the second and third lumbar vertebrae. The line of fracture extends obliquely downward.

Case 11. The patient is a sportsman; he was admitted complaining of pain in the lumbar region that had lasted for seven or eight months. Pasternatski's sign is marked on the right side. Extension, flexion and rotation are very painful in the lumbar region, especially on the right side. The patient's physical state is excellent. There are no defects of development in the osseous system. The skin and the mucous membranes are normal. The gastrointestinal and genitourinary systems are normal. There has been a suspicion of disease of the right kidney. The roentgenogram shows a

Fig. 3. (Film 2685) Case III. Isolated fracture of the transverse process of the third lumbar vertebra, with slight displacement longitudinally.

fracture of the second and third right lumbar vertebral transverse processes with a slight displacement longitudinally (Fig. 2). There is no characteristic rotation or backward turn as described by some authors (Tanton).

Case III. This patient was also a sportsman (riding), who for several months had been undergoing treatment in consequence of continuous pain in the lumbar region which was especially acute when performing gymnastic exercises on horseback. Treatment at the dispensary had been of no avail. The patient was sent to the diagnostic section of the hospital for examination and a conclusion as to his further fitness for sports. The roentgenogram showed a fracture of the left transverse process of the third lumbar vertebra (Fig. 3).

Case IV. The patient was in the cavalry and was referred for a roentgen examination of the sacrolumbar region because of dull aching pains which he could not localize definitely. The chief circumstance which could be noticed consisted in sudden pain in the lumbar region when he moved abruptly or turned around. These pains did not always correspond or coincide with definite movements. Physical examination did not disclose any deviations from the normal as regards skin, bones and articulations. The internal organs and the regions in the neighborhood of the spine were also without any particular deviations. The roentgenogram (Fig. 4) shows no pathologic changes in the sacrolumbar region; however, on the left side the transverse process of the third lumbar vertebra is fractured and displaced. In this case the fracture was found in a casual way. It is noteworthy that during the clinical treatment that followed it was observed that a jerk or a pressure directed towards the fracture caused characteristic pain.

From the above cases it will be seen that besides the possibility of a fracture of the transverse processes after direct trauma there exist fractures which are diagnosed accidentally and which cannot be connected with any trauma.

Fig. 4. (Film 5453) Case IV. Severing of the transverse process of the third lumbar vertebra. The fragment is displaced obliquely downward. Its contours are distinct and prominent in relief. The line of fracture is smooth.

The question arises as to how such fractures are caused.

In all our cases a careful examination of the roentgenograms did not show any evidence of destructive changes in the osseous substance of the processes. Consequently, certain mechanical causes must produce these fractures. It is a well known fact that the transverse processes do not carry any direct burden. They are sufficiently well protected by a thick layer of muscle. Therefore it may be concluded that these fractures arise from an extreme tension of the muscles whose points of fixation are situated at the extreme ends of the processes. This is the more probable because—according to its anatomical arrangement—the transverse process has an arthrosis between itself and the rudimentary remnants of the rib, which fact favors a fracture.

If we take that point of view, we may imagine that a group of strong muscles (m. intertransversalis, later m. quadratus lumborum) bend the spine laterally together with the m. latissimus dorsi and even the m. internus spinae and may at a moment of hypertension cause a fracture of the process.

A considerable hyperextension of the spine in a lateral direction, together with a slight rotation, may be sufficient to cause a fracture of a transverse process.

If such a mechanism of this fracture is possible, the question may arise as to why such fractures are rather rare. Possibilities of hyperextension of the spine are very frequent in every-day life. Such intense hyperextension frequently happens in persons who do not do heavy work. We find an explanation of this circumstance in the physiological peculiarities of the structure of the spine itself. That structure may in some cases even be favorable for a fracture, and the latter occur without any trauma. In other cases, notwithstanding frequent injury to the lumbar region or under conditions of intense physical labor with frequent hypertension of the muscles fractures do not occur. Heitsman (1893) in his handbook on anatomy, referring to Henke's expressed opinion, says that in the spine a rotary movement takes place along all 23 vertebrae (without the five lumbar vertebrae), and that each vertebra rotates to the extent of about one degree.

Consequently when a rotary movement of every vertebra is possible to the amount of about one degree, then the physiological functional capability of the spine may be considered to be sufficient. But it sometimes happens that the mobility of the spine is distributed irregularly as regards its whole length. In some individuals that mobility is greater in the thoracic part; in others, rotation is performed rather in the lumbar part. To put it briefly, this peculiarity depends upon the conditions of the physical development of the growing organism, upon the conditions of labor, upon the results of the illnesses which the individual has had and, finally, the importance of gymnastics and training must not be undervalued which may lead to a considerable degree of mobility of the spine.

The anatomical structure of the thoracic and lumbar sections differ to a certain extent; thus, for instance, while the lumber vertebrae are separated from one another by means of intervertebral cartilages, the cartilages are much thicker between the thoracic vertebrae.

The articular surfaces of the articular processes of the lumbar vertebrae are not closely contiguous and thus do not hinder free rotatory movements. It appears that such movements may be considerable in the lumbar section of the spinal column (Henke).

Considering the mechanism of the movements of the spinal column with its physiological variations of an unequally distributed capability of rotation, we may conjecture that in persons with a strongly developed musculature and with a maximum capability for rotation in the lumbar section of the spine, fractures of the transverse processes may occur comparatively frequently.

That such fractures should happen it is

further necessary that there should be a combination of definite states of the spinal column, i.e., a supertension of the muscles and simultaneously a maximum rotation of the spine. Where these two factors act simultaneously and sharply, creating as it were an insult, a fracture of the transverse processes may ensue and the mechanism of such a fracture can be easily understood. If, on the other hand, there is only one acting factor, i.e., a hypertension of the muscles, while the rotation is slight, either owing to minimum physiologic rotatory possibilities or to the special position of the individual which does not favor maximum rotation, a fracture may not follow.

From the above we may suppose that fractures of the transverse processes without direct trauma occur in individuals whose rotary movements of the spinal column are most intense in the lumbar part of the spine. This physiologic peculiarity, combined with hypertension, is a favorable item predisposing to fracture.

The evidence in the literature sometimes clearly proves the possibility of a fracture of the vertebral processes when the above mentioned mechanism is at work. Such cases are very illustrative. For instance Sezay in 1925 and 1926 described fractures of the vertebral processes in a woman who was carrying a child in her arms when on ascending a staircase, she stumbled and fell on one knee while holding the child up with all her strength. For five months afterwards she had pain in the lumbar region which she attributed to having had a fright. It was only after a roentgen examination that the cause of her suffering was discovered: there was a fracture of the transverse process of the first lumbar vertebra. Another similar case has been published.

Our cases and the facts described in the literature show that a fracture of the transverse processes is possible, due not only to direct trauma, but also to the power of groups of muscles, acting together in certain maximum positions of the spinal column. We have described cases which occurred in persons in their prime and with very well-developed muscles (agricultural laborers before entering the military service).

We must still mention a circumstance which may cause a fracture of the transverse processes. This circumstance concerns so-called everyday, unnoticeable traumas, to which workers become accustomed and which they do not mention when the history is being taken; however these circumstances may also produce fractures of the transverse processes. Some clinicians also insist upon such a possibility, i.e., of habitual everyday traumas which may scarcely have been noticed by the patients. The practical conclusions from our cases and everyday observations do not give any reason to suppose that such may be the prevalent causes of fractures of the transverse processes of the vertebrae. It is difficult to imagine an "unnoticed" trauma the force of which, being applied against a transverse process which is protected by such a thick layer of the large muscles of the back, could fracture the process and remain unnoticed by the patient. It must be supposed that however small the force of the trauma is, it will always be noticed and felt by the patient, if it is strong enough to cause a fracture. Of course I am not speaking of the cases where the patients undergo the effects of great mechanical power (a fall, being crushed by pieces of rock in the mines, etc.); here of course the force of the trauma has far more serious consequences than a fracture of the transverse processes.

SUMMARY

1. A fracture of the transverse processes of the lumbar vertebrae may occur from direct trauma and without it.

2. Cases of fractures of the transverse processes without direct trauma may occur from hypertension of the muscular apparatusof the back and from amarked physiological capability of the lumbar section of the spine for maximum rotation. Only dur-

ing a combined and simultaneous sharp bump-like action of both these factors can a fracture of the processes occur.

3. At present a roentgen examination is the only exact and correct diagnostic means, which can aid the surgical and neurological clinics in discovering the causes of complicated sufferings which may be of an indefinite character and may last for a long time as dull pains in the lumbar region.

4. A fracture of the lumbar processes is a pathologic state which is often observed by surgeons, neurologists and roentgenologists, both within their practice in mining and industrial regions and also in their practice as army and insurance physicians.

5. Tanton's rule, by which the line of fracture is always said to take its course from below and from the inside upwards and towards the outside, has not been confirmed in our cases.

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SOFT TISSUE ROENTGENOGRAPHY

ANATOMICAL, TECHNICAL AND PATHOLOGICAL CONSIDERATIONS

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ANATOMICAL CONSIDERATIONS

THE definition of a soft tissue roentgenogram may be given as a "roentgenogram which shows the soft tissues with the same detail as a conventional roentgenogram of osseous structures." A roentgenogram made according to this standard discloses a tremendous wealth of detail, far exceeding that seen in osseous structures. This necessitates a correlation between the roentgenographic appearance, anatomical features, and, to a certain extent, the physiological findings in order to appreciate any variation from the normal.

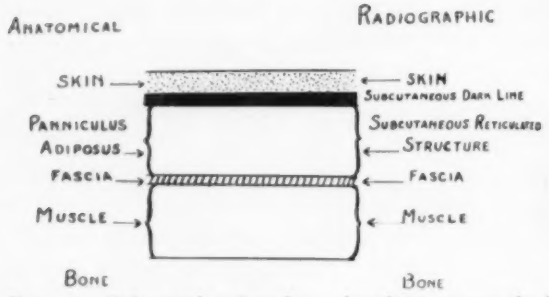

FIG. 1. Schematic drawing showing anatomical roentgenographic classification of the soft parts. The skin, subcutaneous reticulated structure, and fascia are the circumferential cylinders.

A study of the soft tissues from the roentgenographic standpoint will soon convince one of the complexity and high degree of differentiation of the soft parts and the great difficulty in describing what is seen unless a basic and new concept is made.

With this in mind, a fundamental view of the soft parts is taken. They may be likened to a series of cylinders, the outer ones completing the circumference with smaller ones clustered about a center, namely, bone in the case of the extremities, and thoracic and abdominal contents in these regions. These cylinders are composed of various structures, principally muscles, vessels, and nerves, some of which have motion in relation to each other in somewhat similar fashion to joints, while others, particularly vessels and nerves, may be relatively fixed. Between the cylinder groups, particularly the inner ones, and within themselves there are numerous potential spaces. These spaces have a remarkable intercommunication. This is well demonstrated by injecting air following the method suggested by Murray Gratz. We shall refer to roentgenograms made in this manner as "fasciagrams." Clinically the fact that these spaces have extensive intercommunication is indicated by the wide spread of the emphysema in certain cases of puncture of the lung.

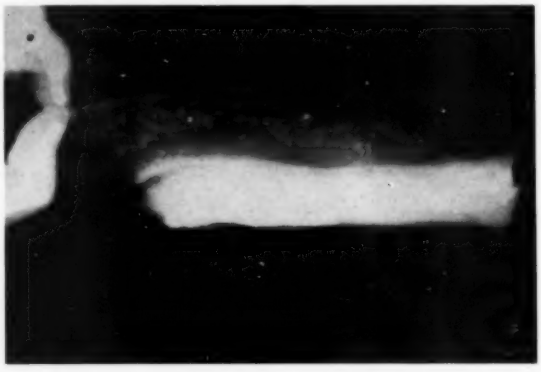

FIG. 2. Roentgenogram of section of anterior abdominal wall. Note subcutaneous reticulated structure and fascia just below. The muscle is compressed and appears amorphous. Subcutaneous dark line is not well shown. Compare this roentgenogram with schematic drawing in Figure 1. (Courtesy of Dr. Wm. Moore.)

The skin is the outermost cylinder and, of course, the limiting membrane. With adequate technique skin can be shown as a homogeneous band of slightly increased density. There is little or no differentiation of the very small histological structures within the skin. The skin varies in size and density in different parts of the body, being

thicker and denser, of course, over the heel and palm. There is a layer of alveolar fatty tissue, sometimes called panniculus adiposus, which lies under the skin. The structure is circumferential and contains small vessels, nerves, and lymphatic channels. Roentgenographically we note numerous fine lines of increased density which tend to have a vertical direction but with definite lateral offshoots forming a network or reticulation. We have called this structure the subcutaneous reticulated zone. The size, density and character of the reticulations vary according to the location in the body. In the heel, for instance, the reticulations are thicker, denser, and have a more pronounced vertical direction. The width of the reticulated zone also varies according to the region, being quite thin in the lower neck and very prominent in the lateral thigh. It also varies according to age and sex, being wider in adult life and thin in children and the aged. It is usually wider in females than in males. The subcutaneous reticulated zone may be modified in various anatomical areas such as the breast, the latter structure being

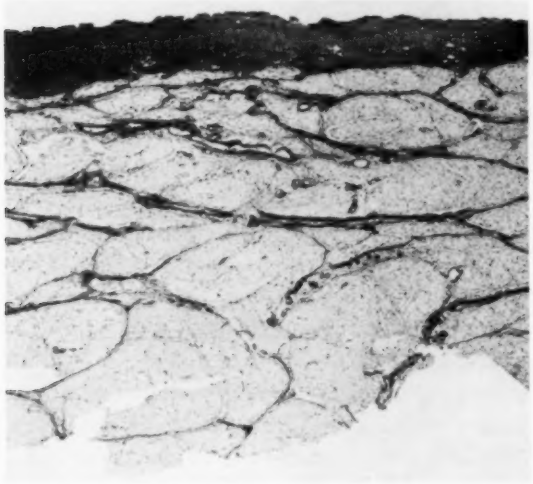

Fig. 3. Low power photomicrograph of skin and panniculus adiposus. Note the reticulated appearance. These pockets are often markedly distended by edema or air. The subcutaneous dark line apparently consists of lower layers of the skin and the uppermost portion of the panniculus. (Courtesy of Dr. Wm. Moore.)

Fig. 4. Air injected into the fascial spaces of the arm in a cadaver (fasciagram). Note the large amount of air between the biceps and the deep muscles. Also note the numerous linear collections of air.

essentially a special modification. Within the reticulated zone, in addition to the vertical reticulations described above, are often seen numerous planes running at right angles to the vertical striations. These vary greatly in size and number and possibly are more characteristically seen in the calf of the leg.

On a soft tissue roentgenogram may often be noted a small line of decreased density lying immediately under the skin. We have called this the subcutaneous dark zone and as far as we can determine histologically it consists partially of sebaceous glands, probably including areolar tissue. It is of little importance from a practical standpoint.

The subcutaneous reticulated zone is based on fascia which also is circumferential. This is important in such regions as the breast where its integrity may be broken by carcinomatous invasion. It appears as a thin line of increased density.

Most of the muscle groups can be well differentiated. Faint lines of decreased density represent the separation between the various muscle groups. The detail within the muscle itself varies considerably. In aged individuals, particularly those who are not naturally well developed muscularly, many lines of decreased density may be seen which represent the separation be-

tween the muscle bundles or fasciculi. According to Gratz these fasciculi form more or less isolated bundles which may be separated by air injection. This probably accounts for the very large number of planes which are seen following the injection of a large amount of air in the soft tissues. The median raphe of the muscle may sometimes be seen as a faint line of increased

Fig. 5. Note detail within the muscles themselves. The linear lines of decreased density represent boundaries between the fasciculi.

density. Summing up briefly, we may say that muscle detail shows more distinctly in children and the aged. In the athletic adult the muscle itself is apt to be amorphous roentgenographically.

It is impossible to show normal periosteum and when this structure becomes visible it is a definite indication of pathology. The solid bone detail, of course, is not visible.

The normal blood vessels can be demonstrated without injection methods, particularly at the flexures such as the knee, elbow, and ankle. This is probably so because of the amount of fat in these regions which is less dense than the vascular structure. It is difficult to differentiate between veins and arteries when the vessels are large. However, with the small vessels this differentiation can often be made. The veins, especially the superficial ones, are usually slightly denser and apt to be larger and more tortuous than arteries. The superficial vessels tend to have a perpendicular direction to the long axis while the deeper vessels tend to run parallel. The smaller vessels, particularly in the veins, are often well shown in the subcutaneous reticulated structure.

The nerves are difficult to show. Occasionally in the popliteal region the popliteal nerve can be seen. However, the larger nerves have fascial sheaths which can be injected with air thus permitting visualization of their detail. This opens a wide field for investigation.

The above anatomical description is subject to modifications in various regions of the body. For this reason a more detailed description of the soft tissue parts which can be visualized in the more important regions will follow.

The roentgenographic appearance of soft tissues has a much greater factor of variability than the bony structure and consequently, in a few instances, the description given below might not fit due to a very unusual muscular development, excessive deposit of fatty tissues, and so forth. A detailed description of roentgenograms of the soft parts in all possible positions would be obviously beyond the scope of this article. An attempt has been made to give the minimum anatomical knowledge necessary for a working knowledge of the more important regions.

An exhaustive discussion of each particular anatomical structure which might possibly enter into the formation of a shadow is not made unless there is some particular diagnostic reason why such a discussion should be of value. The identity of the shadows was determined as far as possible by the following methods: (*a*) postmortem studies; (*b*) observation at operative procedures; (*c*) studies on cadavers

after injection of fascial spaces of air (fasciagrams). This latter method has been found very valuable and has great intrinsic possibilities as a diagnostic method. In addition, arteriograms were studied and cases where extensive arteriosclerosis had outlined the arterial tree were also studied.

The Ankle. The ankle may be examined in the anteroposterior or lateral view but by far the greatest information can be obtained in the latter position. Posteriorly there is a well-defined triangular shadow of decreased density composed largely of fat whose apex points upwards. This area is formed by the tendo achillis posteriorly and the deep muscles of the calf anteriorly. The base is formed by the calcaneus. The posterior tibial vessels run longitudinally in this area and are usually found on the roentgenogram near the shadow of the deep muscles running roughly parallel with it. The skin about the heel is very thick and the subcutaneous reticulated space presents many unusual features. The striations are quite dense and thick and practically entirely vertical, giving rise to a rather striking appearance. The insertion of the plantar fascia into the calcaneus is usually distinctly seen. It gradually fades out and becomes indefinite anteriorly. Probably some of the abductor muscles are also involved in this shadow.

Anteriorly there is only a relatively thin layer of soft tissues over the ankle joint and the dorsum of the foot. The lower anterior tibial vessels and the dorsalis pedis vessels are seen in this area. They are to be differentiated from the shadow of the tendons, when present, by their slightly posterior position and somewhat irregular course. The tendon shadows in this region appear more superficial and are straighter.

The posterior soft tissue triangle is a good area to observe vessels and very often the loose, fatty, areolar tissue becomes filled with hemorrhage when there is a fracture in the neighborhood.

The Knee. There is a wealth of soft tissue detail about the knee. The anteroposterior view is of relatively little importance. The lateral view taken at an angle of 70° gives us by far the greatest amount of information. In the back of the knee and lower femur there is a roughly triangular area of decreased density composed as in the other flexures of fat, the apex of which points anteriorly, roughly towards the joint. The anterosuperior boundary is formed by the deep posterior thigh muscles. The antero-

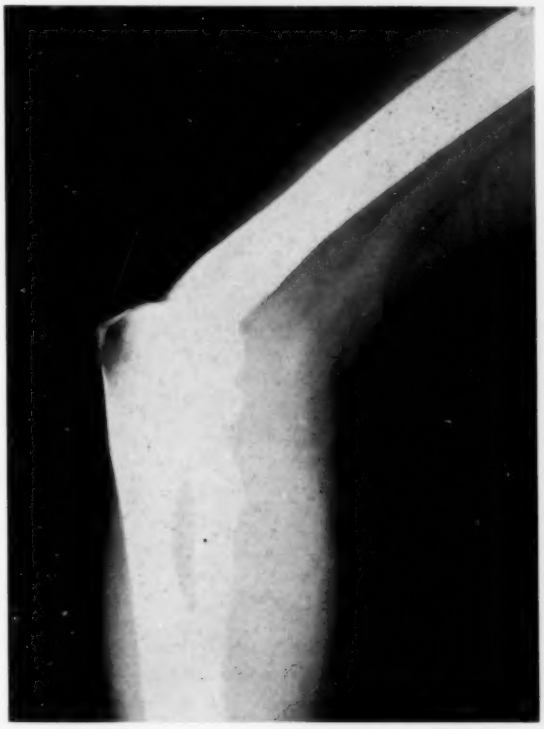

Fig. 6. Normal brachial vessels in a relatively young normal adult. No injection was used.

inferior boundary is formed by the upper portion of the calf muscles particularly the gastrocnemius and plantaris. This portion of the shadow varies largely according to the muscular development and may actually bring this border of the triangle above the lower half of the popliteal space proper.

The popliteal vessels traverse the apical portion of this triangle assuming a fairly characteristic fan shape, particularly in the inferior portion. Below, the course of the popliteal nerve may sometimes be seen if the conditions are particularly favorable. The nerve is usually sharper in outline and runs slightly obliquely with the vessels.

The tendons of the biceps femoris, the semimembranous, semitendinous, and possibly sartorius may cast faint transverse linear shadows which are confusing and may be mistaken for other structures. They generally occupy a more posterior position, however, and can usually be traced into the respective muscle. The saphenous veins are sometimes seen. They usually lie in a plane posterior to the deep vessels.

Fig. 7. Normal vessels in the popliteal region. The popliteal vessels appear as a fan-shaped shadow crossing the posterior soft tissue triangle. The oval shadow above the knee cap represents the suprapatellar extension of the joint space which is filled with fluid. Normally this should appear as an area of decreased density. This roentgenogram was made without injection.

Anteriorly the patellar ligament is distinctly seen as a laminated shadow of increased density which grows thinner as the patella is reached. Following this shadow to the patella one notes an apparent doubling or split, one shadow extending anteriorly and another, posteriorly, to the under surface of the patella. The latter shadow is probably the anterior portion of the prepatellar extension of the joint space and does not represent the tendon. The suprapatellar extension of the joint space runs superiorly under the tendon and shows when filled with fluid as a roughly oval shadow of increased density under the tendon. Below the patella one can note the extension of the patellar ligament to its insertion to the tibia. Below the patella is a joint space which appears as a roughly quadrilateral area of considerably decreased density, oftentimes with a definite reticulation.

The Elbow. The soft tissues of the elbow, particularly in the lateral view, show greater variability, perhaps, than the knee. As in the latter region the lateral view is of more importance but the anteroposterior view may sometimes be of use as the soft tissues project to a certain extent beyond the limits of the bones in this region. In the lateral view, the subcutaneous reticulated structure is wider and more definite anteriorly than posteriorly. We often see an area of decreased density over the lower third of the humerus, the apex of which points posteriorly, the base of the triangle being formed by the lower belly and tendon of the biceps. The inferior border is formed by the shadow of the coracobrachialis muscle. The position of this shadow is quite variable, depending on the muscular development of the individual. The brachial vessels cross this area in a somewhat curvilinear fashion, giving rise to the radial and ulnar vessels in the inferior portion of the antecubital fossa. The shadows of the radial vessels usually run anterior to the ulnar. The cephalic or basilic veins may sometimes be seen running down the midportion of the biceps shadow. They should not be mistaken for deep vessels which are situated more posteriorly. At times it may be quite difficult to identify the vessels about the elbow. The biceps tendon may often be seen extending in an inferior direction to insert in the radial tubercle. This should not be confused with vessels as the latter tend to run parallel to the radius, not perpendicular or oblique in this region. Posteriorly there is relatively a small amount of soft tissue, especially over the olecranon. The subcutaneous reticulated zone is insignificant. The tissue mass above

the olecranon is formed by the posterior muscle groups and present no particular anatomical point of interest. Very occasionally a normal bursa may be seen if physical conditons are correct.

In the anteroposterior view the central soft tissues are obliterated by the bony structure. The soft tissue masses on each side of the lower humerus are formed by the belly of the biceps and triceps. The brachial vessels may sometimes be seen just medial to the lower third of the ulna. A slight amount of rotation, however, may throw the shadow of the artery over the humerus. One often sees an arcuate shadow of increased density lateral to the joint space. This shadow is probably largely that of brachioradialis. Medially to it there may be an area of decreased density. This varies considerably in the normal according to the muscular development, amount of fat present, and so forth.

The Breast. The roentgenographic appearance of the breast has been well described by Warren, Lockwood and others. It should suffice to mention here the great variation in the roentgenographic appearance which the normal female breast may give. It is helpful also to remember that the breast is merely a modified development of the panniculus adiposus and the skin. In connection with the roentgenographic study of the breast the axilla should always be included. This region is best shown in the anteroposterior view with the arm at right angle to the body or as near right angle as possible. The axillary space is a poorly defined triangular shadow of decreased density, the base being formed by the shadows of the edges of the pectoralis major anteriorly and the latissimus dorsi posteriorly. These muscles, of course, extend beyond the strict limits of the axilla. The axillary fascia confine the region to a relatively small area. The anterolateral boundary consists chiefly of the biceps brachii, coracobrachialis, and teres major. The boundary is completed on the anteromedial aspect by the serratus anterior. The axillary vessels are seen running down the arm fairly close to the bone on the lateral aspect. The edge of the pectoralis major should be included in the roentgenogram as far as its attachment, well over the chest wall.

The integrity of the fascia layer and the glandular tissue becomes a matter of considerable importance in the diagnosis of carcinoma. A roentgenographic examination should always include this area.

The Neck. Hay, Pancoast, and others have described the normal aspect in the lateral and anteroposterior view. However, the supraclavicular spaces have not received much attention. These may be of importance because of demonstrations of shadows of enlarged lymph nodes which occasionally escape palpation.

FIG. 8. Roentgenogram of soft tissues of the arm, zone 1, in case of edema. This patient had a mastectomy for carcinoma. Note the exaggeration of the reticulations.

This region is best shown in the posteroanterior and anteroposterior views, the former with the scapulae thrown forward. Here we notice a roughly triangular shadow, the apex of which points superiorly and medially. It is formed by the deep neck muscles medially and sometimes by the outer portion of the first and second

ribs. The base is formed by the middle third of the clavicle and the soft tissues under it. The platysma forms the lateral boundary. In obese individuals the superior portion of the triangle may be obscured completely by the wrinkling of the soft tissues. The superior margin of the scapula is sometimes seen just above the clavicle medially and sometimes slightly above. A faint semicircular shadow of slightly increased density is sometimes seen

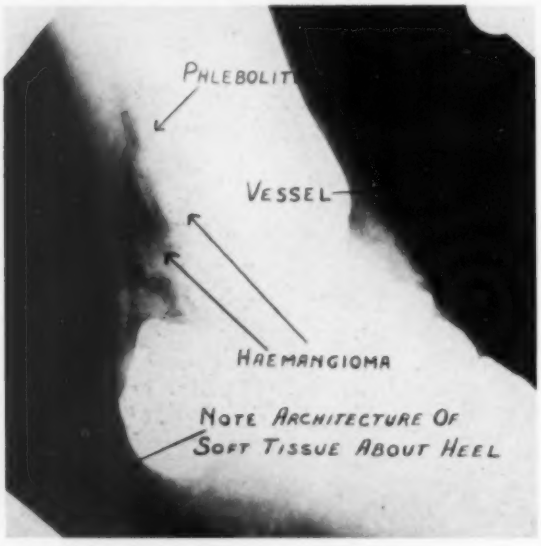

Fig. 9. Racemose non-encapsulated hemangioma. Note the tumor in the posterior soft tissue triangle.

at the base of the triangle near the margin of the scapula. The superior border is well defined. The inferior margin fuses with the soft tissue structures below. I have not been able to positively identify this shadow but it is probably muscular in origin. Its importance lies in the possibility of its being confused with enlarged lymph nodes. Linear vascular shadows can sometimes be seen lying medially. Vascular shadows are more apt to be seen where there is tortuosity of the aorta with displacement of the great vessels of the neck.

In the anteroposterior view, with the scapulae in normal position, the appearance is somewhat similar except that the soft tissue triangle is larger and better defined. The upper margin of the scapula lies well medially and the soft tissue shadow described above is seen but not as prominently and it lies lateral to the shadow of the scapula. Vessels may sometimes be seen in the medial portion, particularly if there is arteriosclerosis of the arch.

TECHNICAL CONSIDERATIONS

While the pioneer roentgenologist at times obtained excellent soft tissue roentgenograms, uniformity of results could not be obtained owing to inadequate equipment. Probably for this reason interest was lost in soft tissue roentgenography until comparatively recently when attention was directed to the roentgenographic possibilities of the breast and larynx. While these investigations were valuable and added greatly to our knowledge, the technique employed was not adequate, the detail of the soft parts being only of fair quality. It soon became apparent to us that a new conception of the scope of soft tissue roentgenography and a new technique were necessary if this were to become a routine procedure. With this in mind and with the definition of a soft tissue roentgenogram as requiring the same detail within the soft parts as a bone roentgenogram, we devised a technique, the essential feature of which was a high milliampere-second ratio with as low a voltage as possible consistent with adequate penetration. This technique was evolved as a result of a great deal of trial and error and comparison of films taken of the same part with existing techniques.

Hitherto the techniques employed were generally faulty in that usually a relatively high voltage was employed and a low milliampere-second ratio, essentially the technique used for bone work. This resulted in a relatively flat roentgenogram in which the finer soft tissue detail was apt to be lost. A contrasty roentgenogram is essential for the soft tissues but this contrast must hold throughout the entire gradation scale. We have coined a word for this latter quality which we call "diatrast." In our early work, generally speaking, sensitive materials were inadequate. Practically all the manufacturers have now developed a

film which is eminently suited for soft tissue roentgenography. However, lately there has been a tendency to increase the contrast while decreasing the diatrast. This has followed a stepping up of emulsion speed. If this continues it may interfere with the development of soft tissue roentgenography.

There is a fairly general impression that expensive high powered machines are necessary for soft tissue work. While of course better results can be obtained with full wave rectified machines capable of fine regulation, nevertheless good work can be done on a simple portable outfit. The voltage used varies from 30 to 70 kv. (peak). Some machines do not have autotransformer steps as low as 30 kv. (peak). In some outfits this adjustment can be made at a small cost. Autotransformer control is necessary and the steps should not be greater than 2.2 kv. (peak). Steps of 1 kv. (peak) are preferable.

The primary line should be adequate, with a minimum of voltage drop or fluctuation. It has been found with the average screen equipment that a ratio of 300 gives the best results. We have found it convenient to use 100 ma. for three seconds, at a distance of 36 inches, the voltage being the variable factor.

No special roentgen tube equipment is necessary. Any roentgen tube which has a reasonably small focal spot and can take the 300 ma-sec., with voltage range specified above should suffice. We do not use filters. In the self-protected roentgen tubes there is often a small amount of filtration. This does not appreciably interfere with the results.

Any intensifying screen will do. However, the ultra-rapid screens are apt to be grainy, which is not desirable. Above all, it is imperative to have the same screen speed if more than one cassette is used for this work. Screens are being developed which are particularly sensitive to soft radiation and these give promise of considerable improvement in soft tissue roentgenography. Their use reduces the milliampere-second ratio considerably. However, most excellent results can be obtained with ordinary screen equipment.

Single screens give slightly improved results but double ones are quite satisfactory. It has been our aim in developing this technique to use standard equipment found in the average roentgen department.

The development of the films is by sight. This is quite essential. The roentgenograms cannot be developed successfully by a strict time and temperature method. The roentgenogram is removed from the developer when the part it is desired to show

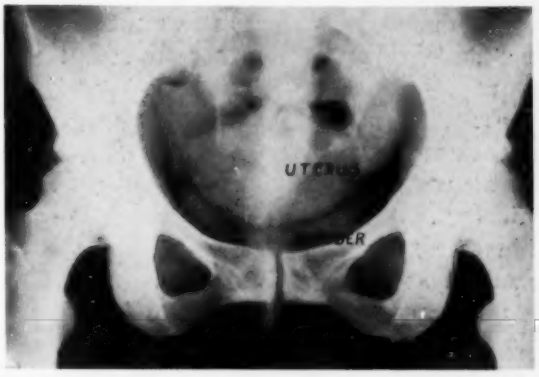

Fig. 10. Roentgenogram of uterus and bladder. The principle of a low voltage and a high milliampere-second ratio can be applied to Potter-Bucky work also. Note lack of detail in most of the bone. The uterus and bladder are distinctly shown.

becomes visible. Determining this requires a certain amount of experience which is readily acquired. We have installed a special dark room for this work in the New York Hospital. This permits the individualization which is so necessary to avoid errors. It is well to have someone in the department particularly interested in this work to pass his or her experience on to others. If no one in particular is interested the technique is apt to fail, particularly at the start.

A safe light which is as strong as can be made without fogging the films is a great convenience in development. We have been experimenting with desensitizing dyes permitting roentgenograms to be developed under a subdued white light. A faint red light is not satisfactory. However, while special dark room equipment is by no

means necessary, careful attention to the details of dark room technique is essential. Solutions must be fresh and at the proper temperature. Above all, fog, from whatever cause, must be avoided. A slight amount of fog will "kill" the fine soft tissue detail which is necessary for accurate diagnosis.

For convenience in estimating the voltage we have divided the structures into three zones. Zone 1 includes the skin, subcutaneous dark zone, subcutaneous reticulated structure, and fascia. Zone 2 includes the muscles and periosteum. Zone 3 is solid bone detail which should not show on the average properly exposed soft tissue roentgenogram.

Practically speaking, therefore, for soft tissue study we make routinely at least two exposures of varying penetration: a light one for zone 1 and a dark one for zone 2. This technique is highly selective. One should not attempt, therefore, to combine too many structures of considerably varying density on the same roentgenogram. For instance, it is better in individuals where the muscle mass varies greatly to make separate exposures rather than to combine them all on one roentgenogram. This holds particularly true for the exposure of zone 2. In zone 1 this difference is less obvious. It is advisable at first to make small trial exposures.

In adapting our technique to an individual machine one should proceed as follows: The machine should be accurately calibrated and if the autotransformer does not reach 30 kv. (peak) it should be so adjusted if possible. Set the machine at 30 kv. (peak) and a milliamperage of 100. Make an exposure of three seconds of the lateral wrist of a normal individual of 150 pounds, the distance being 36 inches, with intensifying screens. With the average machine this should give a good soft tissue roentgenogram of the superficial structures (zone 1) of the wrist in the average 150 pound adult. For zone 2, increase 2 to 3 kilovolts. For the aged, children, and where the part is thin or atrophic, it will be necessary to reduce the milliampere-seconds to 200. If it is impossible to reach 30 kv. (peak) it may be necessary to increase the distance. This, to a certain extent, will compensate. It is advisable, however, wherever possible to have the kilovoltage as the only variable factor. In this manner a chart can be constructed for various regions of the body based on the average adult with two zones or exposures for each part. A measurement technique does not work well in our experience.

The technique of viewing this type of roentgenogram is quite important and has to a considerable extent been neglected. The maximum detail may be seen if viewing is done with illumination of varying color and intensity. An even distribution of illumination is also quite important. We have constructed a special illuminating box in which the source of light is 3 feet from the ground glass. This gives a smooth uniform illumination which improves the viewing considerably.

A little attention to the question of illumination of roentgenograms will often result in bringing out soft tissue detail in the average bone roentgenogram which one would not suspect existed.

PATHOLOGICAL CONSIDERATIONS

The same general laws of physics apply to soft tissue shadows as to those of the shadows of the bone. It will suffice to say that areas of opacity to roentgen rays would appear as light areas on the roentgenogram, and vice versa. It must be borne in mind, however, that the difference in radiopacity in soft tissues is infinitely less than in bone. For this reason, as we have stated above, considerable attention must be paid to the technique of making and viewing these roentgenograms. A thorough knowledge of underlying pathological process is even more imperative than with osseous structures if any understanding of the roentgen appearance is to be made.

Roentgen Findings in Edema, Hemorrhagic Extravasations, and Infections. Edema of the soft tissues gives a character-

istic roentgenographic appearance. There is a marked widening of the subcutaneous reticulated zone while the muscle structure appears relatively thin and the detail within is often obscured. There is a spreading apart of the reticulated pockets with apparent increase in size and density of the reticulation. This is more marked in long-standing edema. This results in a curious mottled appearance which is quite typical. A word should be said, perhaps, about elephantiasis. In advanced cases no muscular detail can be seen; the reticulated pockets have a more vertical appearance and the zone is enormous in width.

Extravasation of blood gives rise to a somewhat similar appearance as edema except that the process is denser, tends to be amorphous, and while the subcutaneous reticulated zone may be widened the reticulations do not extend out so prominently. If the hemorrhage is in the muscle structure there is often haziness with loss of outline between the fasciculi. Calcification can often be seen if the hemorrhage is of long standing. When calcification takes place in the muscles it is apt to have a grid-like appearance. If this occurs near the bone it may be mistaken for osteogenic sarcoma, the differential points being that with hemorrhage one usually notes a clear area between the calcification and the bone, and the characteristic ray-like calcium formation at right angles to the bone is absent. Hemorrhagic extravasations are very often seen about the ankle in the posterior soft tissue triangle, particularly if there has been a fracture.

Inflammatory processes may show a slight widening of the subcutaneous reticulated zone. There is often a faint mottling and the muscles are usually fairly well outlined. The limits of the inflammatory process can often be fairly well defined. In the case of infection with *Cl. welchii* the gas travels along the numerous fascial planes appearing as longitudinal areas of decreased density. Before this stage is reached, however, a faint hazy mottling with minute areas of decreased density can often be seen. Unless a suitable technique is used this early stage is apt to be entirely overlooked. The extent of the infection can be roughly determined.

Soft Tissue Tumors. With the exception of those containing fat or mucus, soft tissue tumors become apparent as areas of increased density. Fatty tumors may be less dense or sometimes of the same density as the surrounding part. Tumors containing mucus are less dense. In studying a soft tissue tumor we note the location, whether or not it is encapsulated, if so, has it broken through the capsule, and also whether or not there is an increased vascularity. The capsule of a soft tissue tumor is a faint enclosing line of increased density. The integrity of the capsule is an important differential point in determining whether or not the tumor is malignant. Benign tumors, in my experience, do not break through the surrounding capsule. The only soft tissue tumors which have a definite characteristic appearance which identify

Fig. 11. Carcinoma of the base of the tongue and epiglottis. Note thickening and increase in density of the epiglottis and unusual posterior position.

their nature are hemangiomas. These tumors may or may not be encapsulated. They have a worm-like structure of increased density which represents the vascular channels filled with blood. They often have large veins running into the tumor.

Osteogenic sarcoma often shows minute specks of calcium which represent minimum calcification in the osteogenic elements of the tumor. In cases where the characteristic ray-formation is absent this may be a valuable diagnostic point. These calcified areas are obliterated with the conventional technique.

Enlarged lymph nodes give rise to more or less circular areas of increased density. If there is considerable enlargement and fusing of the nodes in such conditions as tuberculosis the circular appearance may be lost. Soft tissue induration surrounding tuberculous nodes can often be beautifully visualized, there being irregular areas of increased density with loss of normal outline. Sinus tracts can often be visualized without injection as linear areas of increased density with loss of normal surrounding outline.

Pathological Conditions of the Muscles. Early muscular atrophy often becomes apparent before there is much in the way of reduction in size of the muscle body. The linear shadows of decreased density between the fasciculi become denser and widened. Rupture of the muscle may sometimes be detected, particularly if it occurs in a favorable location. There is a transverse band of slightly decreased density. Evidence of local hemorrhage is often seen.

Periosteum is not visible unless pathological. In the thinner parts subperiosteal hemorrhage can be detected before there is any deposit of calcium. This is of particular value in scurvy. It is our opinion that a roentgenographic study of bone tumor is quite incomplete without a soft tissue roentgenogram. Formation of callus can be detected in many instances at an earlier stage than with the conventional roentgenogram.

Foreign bodies, especially those which are non-opaque, may be visualized, either by their density or because of surrounding infiltration.

Occasionally an arteriovenous aneurysm can be visualized and valuable information as to size and location of vessels can be obtained without injection methods.

On the whole, we have been disappointed with the diagnostic accuracy of roentgenograms of the breast, particularly in chronic cystic mastitis which is exceedingly difficult to differentiate from carcinoma. Roentgenograms of the supraclavicular space and axilla are always included with the breast and at times lymph nodes may be seen which escaped palpation.

Joint Conditions. Thickening of the joint capsule and surrounding ligaments can often be demonstrated. The very earliest calcification in or about the joint becomes demonstrable. However, loose cartilage which has not become calcified can only occasionally be demonstrated. Joint effusions are well shown as areas of slightly increased density, conforming to the anatomical limits of the joint space.

Vascular Conditions. The arteries and veins can be shown without injection methods, particularly at the flexures. The very earliest calcified deposits become visible, and tortuosity of the arteries can be seen. Varicose veins can be well shown and are more tortuous, wider, and denser than normal. The superficial ones tend to run obliquely with the long axis while deep veins tend to run parallel. The detection of varicosity of deep veins may be important in deciding whether or not injection therapy should be undertaken.

The field of soft tissue roentgenography is a relatively new one and there are many problems yet to be solved. The opportunity for investigation is wide and a plea is made for more interest in this type of work.

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DIRECT VENOGRAPHY IN OBSTRUCTIVE LESIONS OF THE VEINS*

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SUCCESSFUL roentgenographic visualization of the veins of the living human subject after direct intravenous injection of a radiopaque solution was accomplished by Berberich and Hirsch in 1923. They used a 20 per cent solution of strontium bromide. This method of study, however, was not used much until the advent of the various iodide solutions that permitted successful intravenous urography. In 1930 and 1931 Ratschow reported successful direct venography first with uroselectan (sodium-2-oxo-5-iodopyridine-N-acetate; now called iopax) and later with abrodil or skiodan (sodium-mono-iodo-methanesulphonic acid). In 1934 Edwards and Biguria reported the use of diodrast, a 35 per cent solution of 3.5 diiodo-4-pyridone-N-acetic acid diethanolamine, and felt that it was somewhat less irritating than skiodan and possessed just as much radiopacity. These authors and others, particularly in Germany, have studied normal veins or simple varicosities. Apparently, direct venography has not been used in the study of obstructive lesions of veins, with the exception of one case described by Edwards in which there was obstruction of the inferior vena cava.

There are many possibilities for the study of the pathology and normal and pathologic physiology of the veins of the extremities by direct venography. Injections may be made at many different points and the patient may be placed in different postures. Rates of blood flow may be studied with the fluoroscope, stereoscopic plates may be taken, the effects of venous compression at various points may be noted, and the effects of treatment may be followed.

We have used diodrast as an injection medium in this study. It has definitely less radiopacity than thorotrast (a colloidal suspension of thorium dioxide), but for medium-sized and large veins it is sufficiently opaque to secure good visualization; like the other iodides, however, it is rapidly excreted from the body. Iopax and skiodan cause pain during injection. Diodrast does not cause pain and apparently does not irritate the endothelium of the veins; it produces only slight transient irritation of the subcutaneous tissue if accidentally injected outside the vein.

In any study of veins and venous blood flow by direct venography it must be realized that veins have valves, and that even if some of these are incompetent, it is impossible, even with tourniquets, to fill the entire venous system with the injection medium. If no tourniquets are used, the largest part if not all of the injection medium will proceed toward the vena cava by the most direct path. If an anatomic study of the veins of an extremity is desired, in an effort to visualize as much of the venous system as possible, indirect venography after intra-arterial injection is the only satisfactory method (Allen and Barker).

The technique used in this study was quite simple. All subjects were placed in the supine position. Injection was made in the long saphenous vein or one of its tributaries in the lower part of the leg when visualization of the upper long saphenous, upper femoral, or iliac veins was desired; in a superficial vein of the outer side of the foot or posterior part of the calf when visualization of the short saphenous, popliteal, or lower femoral

* Read before the meeting of the Central Society for Clinical Research, Chicago, Ill, Nov. 1–2, 1935.

Fig. 1. Normal leg. Diodrast was injected into a tributary of the long saphenous vein in the upper part of the calf. The long saphenous, external iliac, and common iliac veins are well visualized.

veins was desired, and in the median basilic vein at the elbow when visualization of the axillary and subclavian veins was desired. Venograms were also taken of the external jugular and median cephalic veins after injection in these veins at a more distal point. A tourniquet or manual pressure was used to distend the vein, and under sterile precautions direct venipuncture was made with a number 21 needle attached to a Luer syringe. No local anesthetic was used except where injections were made directly into the long and short saphenous veins which are accompanied by sensory nerves. The tourniquet was removed before injection was begun. Twenty cubic centimeters of diodrast were injected in veins of the lower extremity, 10 c.c. in veins of the upper extremity. Injection was made steadily and rapidly, fifteen to eighteen seconds for 20 c.c., and eight to ten seconds for 10 c.c. The roentgenogram was made just as injection was completed.

It was found necessary to adapt the roentgenographic technique to the part under investigation. Since a maximal degree of contrast was desired, a Potter-Bucky diaphragm was used. For visualization of the saphenous, femoral, and iliac veins the following roentgenographic factors were used: 90 kv. (peak), 60 ma., 30 inch tube-film distance, and time of exposure, one and one-half seconds. The tube was angled 5° cephalad. For examination of the axillary and subclavian veins the following factors were used: 70 kv. (peak), 60 ma., 40 inch tube-film distance, and time of exposure, one second. Before in-

Fig. 2. Thrombophlebitis with partial obstruction of the external iliac vein. Diodrast was injected into a tributary of the long saphenous vein in the upper part of the calf. A definite narrowing of the lumen of the external iliac vein is noted, with dispersal of the diodrast into tortuous collateral veins in this region; these reunite with the common iliac vein.

jection was started the patient was properly centered on the roentgenographic table and the film placed in position so that exposure could be made without delay.

It was found that even with rapid changing of films, diodrast passed out of the veins too rapidly to secure visualization in more than one film. Successful venograms were made in 37 cases: 19 of veins in the lower extremity, 17 of veins in the upper extremity, and one of the external jugular vein (Figs. 1 to 8 inclusive).

Pain was not felt in the veins during or following injection, nor did thrombosis occur in the veins after injection. In a few instances a small amount of diodrast was accidentally injected outside the vein; mild to moderate pain and a slight inflammatory reaction followed, but this lasted less than twenty-four hours and there was no necrosis of tissue. Nausea developed in 3 cases and 2 of these patients vomited within two minutes after injection was completed; several others complained of "light-headedness." These reactions were all very transient and probably due to the rapidity of injection. Nausea and vomiting occurred only in cases in which patients received 20 c.c. of diodrast, and in cases of extensive venous obstruction in which there was marked slowing of the venous blood flow. Mild urticaria developed in one case within fifteen minutes after injection; the patient later said that this had occurred previously when she had taken iodides.

Following the use of this technique, normal venograms can be described as fol-

Fig. 3. Extensive thrombophlebitis of the iliac and femoral veins. Diodrast was injected into a tributary of the long saphenous vein in the upper part of the calf. The medium has passed out of the long saphenous vein into numerous collateral tortuous veins in the upper part of the thigh and across the pubic region to the opposite side. The comparatively low level which diodrast has reached after eighteen seconds is an index of the markedly delayed blood flow.

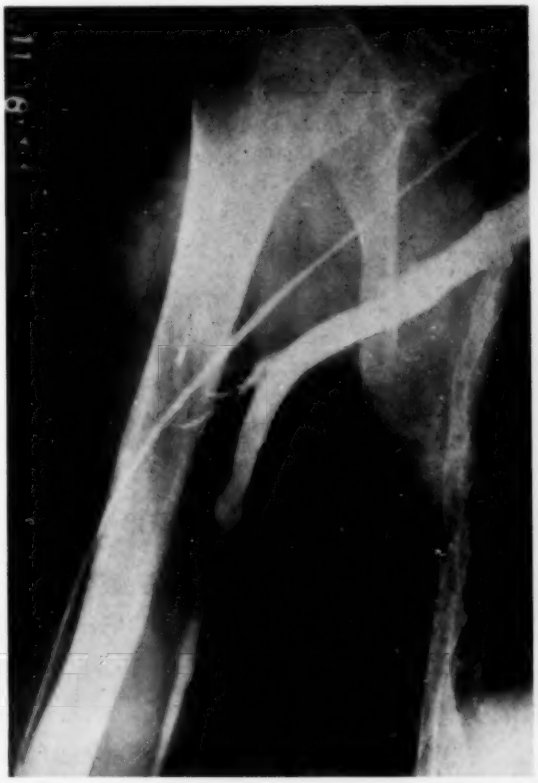

Fig. 4. Normal arm. Diodrast was injected into the median basilic vein at the elbow. The median basilic, axillary, and subclavian veins are well visualized. The median cephalic vein is also filled in this subject.

Fig. 5. Extensive axillary thrombophlebitis. Diodrast was injected into the median basilic vein at the elbow; it has left this vein at a distal level and passed through the axilla to the thorax, through many tortuous collateral veins.

Fig. 6. Obstruction of the superior vena cava as a result of lymphoblastoma. Diodrast was injected into the median cephalic vein at the elbow. The median cephalic vein is well visualized to the thorax, but from this point the diodrast has passed into many collateral veins at the base of the neck instead of directly into the subclavian vein. Small collateral veins are also seen in the deltoid region.

lows: in the upper extremity, the median basilic vein after its injection and the axillary and subclavian veins are clearly visualized to a point where the subclavian passes the lower margin of the clavicle. The density of the diodrast shadow diminishes from the point of injection proximally as large tributaries join the veins mentioned. Retrograde visualization of tributaries is variable, and usually for a short distance only. Occasionally a few small collateral vessels are shown; these are fairly straight. Moderate saccular dilatations are shown at the sites of valves in the median basilic and axillary veins. The median cephalic vein is visualized after its injection to a point where it joins the sub-

Fig. 7. Axillary and subclavian thrombophlebitis. Diodrast was injected into the median cephalic vein at the elbow and passes through a tortuous collateral into the external jugular vein which is well visualized.

clavian, and the subclavian vein is faintly shown to the lower border of the clavicle. In the lower extremity, the long saphenous vein after its injection is well visualized to its juncture with the femoral vein, and from this point the femoral and iliac veins are more faintly seen to the beginning of the inferior vena cava. Shadows of the iliac vein are usually somewhat striated. There is little or no retrograde flow into collateral veins or into the femoral vein in the thigh. Sites of valves usually are not

shown. Similarly, in the short saphenous vein the medium passes directly into the femoral vein at the knee, and only these veins are visualized.

Extensive obstructive lesions of the iliac or axillary veins present a strikingly different venographic picture. The diodrast was shown in many diverging and tortuous collateral veins, and the main venous trunks were visualized for only a short distance from the point of injection. The level in the limb to which diodrast penetrated was a considerable distance from the vena cava. Venograms of more localized and incomplete obstructive lesions were marked by localized dispersal of the diodrast into a cluster of tortuous tributary veins, by increased prominence of the dilatations at valve sites, and by increased retrograde injection of anastomosing channels.

In the case of obstructive lesions of the long saphenous vein diodrast entered a few collateral channels below the point of occlusion, uniting again in the external superficial or deep femoral veins; in obstructive lesions of the short saphenous vein it passed through collateral channels over into the long saphenous system.

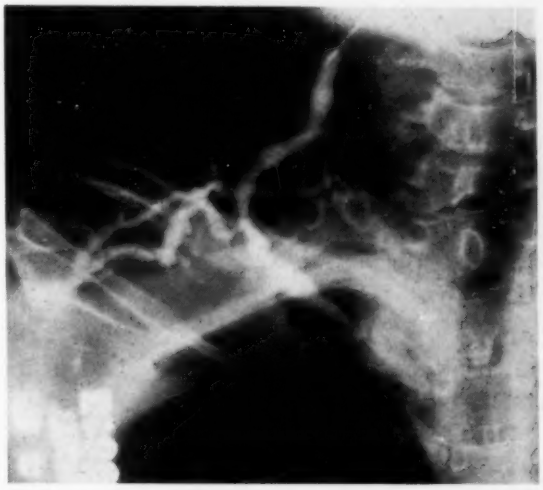

Fig. 8. Obstruction of the external and internal jugular veins as a result of the scalenus muscle syndrome. Diodrast was injected into the external jugular vein. The external portion of the vein is displaced, laterally, and the usual mesial branch is shown only as a small tortuous vein. Most of the diodrast passes through large distal collateral veins into the subclavian vein at a more distal point.

COMMENT

In all cases of obstructive venous lesions the original diagnosis was made clinically, and there was no pathologic or surgical confirmation. However, typical cases were selected in order to note the changes, and the venographic evidence is so definite that it is in itself a confirmation.

The value of direct venography in obstructive lesions of the veins can be summed up as follows: (1) It may aid in evaluation of disturbances in rate of venous blood flow. (2) It may aid in localizing and determining the extent of an obstructive lesion. (3) It may be of diagnostic aid in obscure cases, particularly when extrinsic obstruction is suspected.

The simplicity and safety of the method recommend it. Contraindications are idiosyncrasy to iodides and recent (within two weeks) acute thrombophlebitis. The method has definite limitations, but there also are many possibilities for variations and improvements in technique.

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TUBERCULOSIS OF THE TUBEROSITY OF THE ISCHIUM

CASE REPORT

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TUBERCULOSIS of the tuberosity of the ischium would appear to be a rare condition; the only available reports in the literature for the last thirty-five years that I can find being that of Zellmeyer, who in turn mentioned 5 other cases, and that of Blankoff, who presented one case. Odelberg reported 4 cases of inflammatory processes of the ischium and adjacent part of the pubic bone. Inoculation into guinea pigs, however, proved negative.

The following case, followed completely from diagnosis to apparent cure and definitely proved as tuberculous in origin, is added to the literature.

J. S., male, aged thirty-three, was first seen on January 25, 1934, one-half hour after he slipped in getting a roll of newsprint paper, fell back and hurt his right thigh against an adjacent bench.

Physical examination revealed a well-built male adult, with a local condition in the right buttock. The latter was seen to be full and reddened. On palpation, a sense of induration and hardness was noted with local tenderness in the region of the tuberosity. Roentgen examination, made immediately, showed the destructive area involving the right ischial tuberosity with a circumscribed wall which apparently was broken down below. The soft tissues showed an increase in density with increase in size of the right buttock (Fig. 1).

Consultation on January 30, 1934, with Dr. Harry C. W. S. de Brun was had, and the opinion was that we were dealing with a broken down cystic area in the region of the tuberosity.

On February 10, 1934, under novocaine anesthesia, an attempt at biopsy was made, with Dr. Milton Friedman, and a punch trocar was inserted. Immediately upon the insertion, broken down necrotic matter and pus came through the opening of the cannula. A smear of the pus was taken, and a culture of the pus made. We now felt that we were dealing with a low grade chronic osteomyelitis which was encysted similar to a Brodie's abscess, and that the trauma might have broken down the wall, causing the evacuation of pus into the soft tissues. Laboratory reports of the smear on microscopic examination showed a very occasional pus cell with a great deal of amorphous material, and no bacteria. Culture examination was negative on blood agar plates and dextrose broth.

Guinea pigs were inoculated with 1 c.c. in each groin on February 13. The guinea pigs died on March 5, and smears made from the inguinal lymph nodes revealed tubercle bacilli. In view of these findings the diagnosis of tuberculous osteomyelitis of the tuberosity of the ischium was established.

Roentgenograms of the chest were then taken in an attempt to establish a primary focus. These showed a Ghon tubercle in the right third space anteriorly. There was no other evidence of parenchymal infiltration.

Course. Subsequent to the aspiration, a fistula developed with the opening of the sinus at the lower and inner quadrant of the right buttock. From this, clear seropurulent fluid continually discharged. Attempts were made to close up these sinuses by local Kromayer treatment and packing with iodoform gauze, soaked in warm liquid radolatum.

Because of the presistence of the sinus, it was deemed advisable to cut down on the affected area and remove the sequestra as well as to sterilize the tract. On May 4, 1934, at the Broad Street Hospital, with Dr. Anopol, incision was made into the right thigh, posteriorly, and a great deal of calcareous material was removed, the site swabbed with 3.5 per cent tincture of iodine, and then the wound was packed with vaseline gauze. A plaster spica was applied.

Beginning on May 11, injections of gadusan (colloidal copper morrhuate) were given intramuscularly and intravenously. The postoperative course was very quiet and normal. The

sinus at the lowermost junction of the wound still persisted, however. The spica was removed on July 2, 1934, and a new one applied. Patient was discharged from the hospital on July 5. On August 25, 1934, the cast was completely removed.

Roentgen therapy was then instituted at the X-Ray Department of the Post Graduate Hospital, Dr. William H. Meyer, director. Treatments were given on alternate weeks to the anterior and posterior regions. After a course of five treatments, as in the following table (Table 1), the sinus still persisted. At the suggestion of Dr. Meyer, Beck's paste was injected into the sinus, the opening closed with collodion, and roentgen therapy continued. After the last treatment, on October 25, the sinus closed.

Roentgen examination on December 6, 1934, showed almost complete filling in of the area of destruction, except for a thin margin along the lower lip. The tissue appeared to be of firm density, akin to bone. On December 20, patient was discharged as cured.

Fig. 1. Destructive process in the tuberosity of the ischium.

Tuberculosis of the bone is a chronic inflammatory osteomyelitis commencing usually in the cancellous bone and embolic in origin. The pathology is that of tubercle, the zone of lymphocytes surrounding the central mass of endothelial cells. With the spreading of the disease, the bone constituents show characteristic changes. The marrow during the first week gives rise to a greater number of polymorphonuclears, this being a leukoblastic reaction. As a result of the toxins, lymphocytes replace the polymorphonuclears. Later still, fibrosis develops and in time the original focus is walled off by fibrous tissues.

Lamellar structures show both osteoporosis and osteosclerosis, the former preponderating. The destructive changes are

Table I

Date	Region	kv.	ma.	Distance	Filter	Roentgens
9-18-34	Posterior	135	5	inches 11	0.25 mm. Cu 1.0 mm. Al	250
9-25-34	Anterior	200	7	16	0.5 mm. Cu 1.0 mm. Al	200
10- 2-34	Posterior	200	7	16	0.5 mm. Cu 1.0 mm. Al	300
10- 9-34	Anterior	200	7	16	0.5 mm. Cu 1.0 mm. Al	200
10-16-34	Posterior	200	7	16	0.5 mm. Cu 1.0 mm. Al	200
10-25-34	Anterior	200	7	16	0.5 mm. Cu 1.0 mm. Al	300
	Posterior	200	7	16	0.5 mm. Cu 1.0 mm. Al	300

Fig. 2. Lipiodol injection into the sinus leading to the bone.

due to the osteoclastic action and the erosive action of the cellular granulation tissue. The osteosclerotic reaction, analogous to the fibrosis in the marrow is produced by the osteoblasts, which deposit fresh layers of bone on the lamellar surface, increasing the thickness and density of the bone. The periosteum is later stimulated to activity as a result of the underlying bone disease.

Tuberculosis of the bone may be localized as the nodule in the lungs, or spreading as the diffuse type in the lungs. In the local forms the central caseous nodule is surrounded by a zone of fibrous tissue. Rarefaction results in complete lamellar absorption. In the spreading form, the walling off process is insufficient, the surrounding zone of gray infiltration representing granulation tissue which has not yet become caseous. Necrosis supervenes before rarefaction has had time to proceed far and large sequestra are formed. The periosteum finally lays down a supply of bone. The disease may spread down the medullary cavity to involve the greater part or the whole of the shaft. It may spread to the periosteum and, breaking through, form a subperiosteal or deep cold abcess. It may involve the soft parts, forming a cold abscess, which ultimately discharges through the skin.

Fig. 3. Beck's paste injection prior to final roentgen treatment.

The first indication of tuberculosis in the bone as revealed by the roentgen ray is usually osteoporosis. Small circumscribed areas of cancellous destruction appear and later the dense amorphous sequestrum may be seen at the primary focus. Because these sequestra are loose in texture and surrounded by fairly dense and caseous matter and granulation tissue, they are usually difficult of designation on the roentgenogram. The cavities appear hazy, bone detail is lost and if the lesion is very old, there may even be some increase in the density of the interior.

Fig. 4. Stage of repair.

In a great many cases, no reaction in the outer layers of bone is present. If the disease is slowly progressive, it may give rise to a fusiform swelling with slight thickening of the periosteum. The thickening may extend for some distance from the focus of the disease. Repair is indicated by increased density of the bone

trabeculae which now show a coarser mesh than normal.

Zellmeyer points out that tuberculosis of the tuberosity of the ischium should occur only in the adult, since the epiphyseal center does not ossify until after the age of fifteen. According to Terillon bone complications usually develop at the most active osteogenetic points, which are usually those centers near the cartilages of union. Therefore, in the first twelve or thirteen years of life, the bone diseases of the pelvis always take place around the center of the bone in the cotyloid cavity, or around this cavity. After the age of fifteen, the secondary centers of ossification become involved.

Reference is made by Zellmeyer to the 3 cases involving males, one fifteen years of age, the second twenty, and the third twenty-three, reported by Terillon, Gant and Fevier, respectively. The age of occurrence is then in the young, after the age of fifteen, when the secondary center for the tuberosity appears. No generalization respecting sex can be made in view of the rarity of the reported cases.

Clinically, the evolution is slow, the course indolent. The case of Terillon presented the picture of a common anorectal fistula. In those of Fevier, Gant and Denuce, the onset was noted by a dull pain progressing slowly, accompanied soon by a limping gait; in that of Gant, with sciatic nerve type radiating pain, in addition.

In the stage of abscess, the pus usually spreads behind the adductor magnus muscle, though it may appear in front of the genitocrural fold. Fistulous tracts may occur along the great sciatic nerve or between the tendons of the posterior muscles of the thigh, as well as the rectal and towards the urethral bulb. In the case of Rose there were three fistulous tracts of which only one led to the ischial tuberosity.

The three factors in establishing the diagnosis are, according to Zellmeyer: (1) exploration of the tract and seeking the denuded bony point, which can only be done where the fistula already exists; (2) roentgenography, which not only gives the picture of the lesion, but also makes possible an appreciation of its extent, and (3) local tenderness at the level of the tuberosity of the ischium. This is very accessible when the lesion is on the external side of the tuberosity. When it exists on the internal side, rectal palpation may be of help. To the foregoing three elements must be added a fourth, the finding of the tubercle bacillus either on smear or on inoculation, or the discovery of the tubercle in the necrotic bone tissue.

Differential diagnosis must be made from abscess of the soft parts either simple or extending from some other part of the pelvis or vertebral column. In the presence of acute symptoms, hip disease, rheumatic fever, and osteomyelitis of the bone must be ruled out. Fistulous tracts of the rectum or genital organs must also be considered in the differential diagnosis; syphilis, Brodie's abscess, and rarefying tumor processes are other considerations.

PROGNOSIS AND TREATMENT

Tuberculosis of the ischium occurs in the young and is relatively easy to cure. In an adult, visceral complications are less often present. Early and radical treatment will produce a rapid and early cure. Secondary infections through the neighboring anal orifice and the difficulty of keeping the wound sterile are two major factors. Thus Fevrier's case formed an acute abscess in the space of Retzius; Denuce's also had secondary infection. Palliative treatment may be tried in the stage of closed abscess by aspiration followed by modifying injections, such as iodoform ether or creosoted glycerine or gadusan. But, if after two or three treatments there is no improvement, or the abscess bursts, surgical intervention is necessary for the fistulous tract. The detached sequestra are removed and the pocket curetted. Where simple curettage fails to produce cicatrization, it may be necessary to do a partial resection, subperiosteally. Finally, rest in

bed and immobilization are necessary to complete the cure.

Blankoff reports the case of a male, aged twenty-one, with a fistulous tract, through which a stylet was directed towards the ischium between the adductor magnus and semimembranosus, with local tenderness on the tuberosity of the ischium, and roentgen findings of destruction of the tuberosity with many disseminated bony nodules, the whole, pale, decalcified and without definite structure. Laboratory findings were positive for the tubercle bacillus. The treatment consisted of operative removal of sequestra, and curettage of the tuberosity. Blankoff was not able to report on the final result of the case.

SUMMARY

To the seven cases of tuberculosis of the tuberosity of the ischium, reported in the French literature, apparently the first in the English literature is here added, with the diagnosis definitely established and cure obtained.

Thanks are expressed to Dr. William H. Meyer for his opinions and advice throughout the case, and to Dr. N. J. Furst, who was of frequent help in the interpretation of the films.

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OSTEOPOIKILOSIS

REPORT OF FOUR CASES

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OSTEOPOIKILOSIS is a condition of the bones characterized by condensed areas varying in size from 2 mm. to 2 cm. and varying in shape from small, round to long rod shapes.

These condensed areas have been noted in all the bones except the skull. They are present in the ends of the long bones and absent in the midportion. They occur in the spongiosa and have no connection with the cortex.

This condition has been reported under various names such as osteopathia condensans disseminata, osteopoecile, multiple enostosis and spotted bones.

The first case of record was that of Albers-Schönberg[1] in 1915 and since then there have been about 24 cases recorded in the literature. Wilcox[1] in 1932 reported that a search of the records showed 17 cases, to which he added 2 of his own. In 1933, Wilcox[2] reported 23 cases re-

FIG. 2. Case II. Compare with pelvis of Case IV. These are brothers.

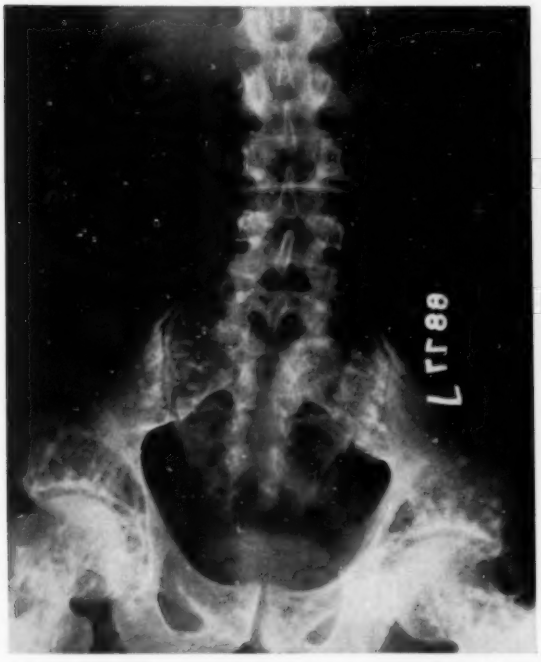

FIG. 1. Case I. Showing pelvis and lumbar spine.

FIG. 3. Case II. Forearms, wrists and hands showing condensed areas.

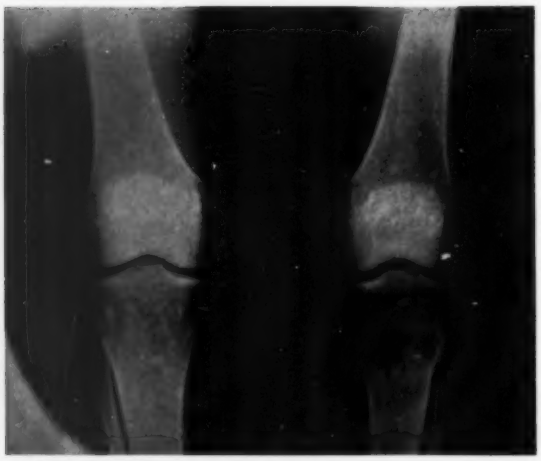

Fig. 4. Case II. Roentgenogram of knees, showing condensed areas in ends of long bones. Note size.

corded. In July, 1934, Nichols and Shiflett[3] reported a case of osteopoikilosis complicated by osteochondroma, which had been under observation since 1916, and so far as the osteopoikilosis was concerned, there had been no change in size, distribution, or density of the areas.

Fig. 5. Case II. Showing condensed areas in ends of long bones.

The etiology of osteopoikilosis is unknown and various theories as to its cause have been advanced. Typhoid has been mentioned. The only histopathological report of this condition was made in 1931 by Schmorl,[1] whose report, summarized, determined that the condensed areas were entirely in the spongiosa and were not

Fig. 6. Case III. Pelvis of infant; daughter of Case II and niece of Case IV. Note small condensed areas in pelvic bones. Trabeculae are excessively thick and dense.

related in any manner to the cortex; that the condensed bone area was thickened trabeculae which tapered out as it merged into the surrounding normal spongiosa.

Osteopoikilosis is symptomless and is diagnosed only by the roentgen ray. Most of the cases have been discovered accidentally as a result of roentgen examination for some other condition. The consensus is that the condition is hereditary; that it occurs in both sexes, and that it is a structural anomaly.

CASE REPORTS

Case I. L. H. A., male, aged thirty-five, was admitted to this hospital in December, 1930, with a tentative diagnosis of renal calculus. Roentgenograms of the kidney areas were negative for renal calculus, but the presence of condensed areas in the vertebral bodies led us to roentgenograph the pelvis and long bones from which a diagnosis of osteopoikilosis was made. In this case the spotted condition was noted in all bones except the skull and ribs. There was no pertinent medical history. No history of typhoid.

The next three cases are of special interest being familial: brothers and daughter.

Case II. L. H., male, aged thirty-nine, admitted to this hospital in September, 1934, with a diagnosis of arthritis, chronic, wrists and left ankle; pyorrhea alveolaris, moderately advanced. Following extraction of teeth, the arthritis subsided and he was discharged, improved, after twenty-three days in the hospital. He fractured a bone in his left foot in 1931 and it was roentgenographed. The spots were noted in the bones of the foot and tibia and fibula, but his physician attached no importance to this finding. He had the usual diseases of childhood, but no history of typhoid. He is the eldest of 10 children. He is married and has a female child, aged four. Roentgenograms were made of this infant's pelvis and long bones.

Fig. 7. Case III. Showing condensed area in tibia.

Fig. 8. Case IV. Roentgenogram showing pelvis. Case II and Case IV are brothers.

Case III. Female, aged four, daughter of Case II. Small condensed areas are to be seen in the pelvic bones. The epiphysis of the femora and tibiae show increased density of the trabeculae, but no definite spots. There is no history of illness in this case.

Case IV. M. H., male, aged twenty-nine, brother of Case II and uncle of Case III. Roentgenograms show osteopoikilosis in all bones, except the skull and ribs. There is a marked similarity in the distribution, size and arrangement of the condensed areas in the films of Cases II and IV. This young man had the usual diseases of childhood, but there is no history of typhoid. These last two cases were roentgenographed to determine the presence of osteopoikilosis. Efforts to obtain roentgenograms of the other members of this family have been initiated, and in Case III yearly observation will be attempted.

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THE FIVE GRAM RADIUM PACK*

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IN SO many instances have we found radium therapy to possess distinct advantages over all other means of treatment for surface malignancies that we felt if we could produce the same effect on malignant neoplasms in the interior of the body we would be going a long way towards eradicating many cancer lesions. Experience seems to indicate that there is undoubtedly a more effective biological action on neoplastic tissue from gamma rays of radium than from the usual forms of roentgen rays. With the high radiant energy available from the roentgen tube it is possible to utilize a much greater treatment distance than is practical with even the largest radium pack. Because of this difference in distance, the depth dose with roentgen rays is much higher than that obtained with the radium pack, as normally used, and yet the biological effect on the tissue at the same depth seems more pronounced with gamma radiation.

Chiefly for this reason attempts have been made to duplicate, if possible, by roentgen rays the effect of radium. Thus, endeavors have been made to increase the tube voltage so that the resultant roentgen rays would be of equivalent quality to that of gamma rays of radium. In this manner it has been shown by physical measurements that roentgen rays produced at approximately over 1,000,000 volts will be equivalent to gamma rays given off by radium.

In this connection we made a study of the effect of intensive radium therapy with a large radium pack, consisting of 5 grams of radium, with the idea of delivering to the patient over a long period of time a fractional daily dose of gamma rays sufficient to destroy neoplastic tissue more or less distant from the surface of the body and without permanently destroying normal tissues through which the gamma radiation has to pass. This assumes considerable importance in the treatment of lesions of the bones, stomach, mouth, throat, and female organs. The comparison of this method with that of prolonged roentgen therapy for larynx lesions was reported by us at The American Congress of Radiology, September, 1933, and subsequently published in *Radiology*.[1]

After careful consideration of all the work we have so far carried out with the 5 gram pack, it is our strong opinion that this is a really worth-while addition to our armamentarium, and is productive of good results in the treatment of malignancy.

To make the 5 gram pack most flexible and easily available for all purposes we have devised a portable outfit which, except during a short interval of time required in making some moderate changes in the design of the radium holder, has been in continuous service on the Cancer Division at Bellevue Hospital since 1932 and is described in *Radiology*.[2]

It is placed and used in a special lead-lined room on the radium ward and in its present form has proved so serviceable that no change of design has been found necessary since it was first constructed, except for the radium holder. This latter is now more nearly cylindrical in shape, thereby readily allowing for increased rotation in all directions. The radium is placed in a drawer-like container which may be safely locked and sealed in position. The radium is evenly distributed over the open area in the lead cylinder.

[1] Kaplan, I. I., et al. Protracted external irradiation in treatment of carcinoma of the mouth and throat; comparison between x-rays, 5-gram pack and small radium pack. *Radiology*, 1934, *23*, 339–354.

[2] Kaplan, I. I. Practical radium pack for bedside use. *Radiology*, 1931, *17*, 148–150.

*Read in a symposium on Radium Packs at the Twentieth Annual Meeting, American Radium Society, Atlantic City, N.J., June 10–11, 1935.

The 5 gram pack we employ (Fig. 1) has the following characteristics:

The radium in the form of 100 tubes, 50 mg. each, is filtered through 0.5 mm. platinum plus 5 mm. lead, equivalent to a total of 6 mm. lead. Although all beta and soft gamma rays may be filtered out by 1 mm. platinum, we employ a filter equivalent to 3 mm. of platinum in order to absorb all but the ultrashort gamma rays, those which are still not possible of production with roentgen apparatus.

We use a portal size of 8×10 cm., because we find it most effective in giving the optimum effect without overexposure of adjacent normal tissues. The portal size is somewhat larger than those used elsewhere, but we believe it gives even distribution of radiation. This portal size when employed for lesions of the neck covers the local involvement and the gland drainage area.

In most instances the distance used in our method of treatment is 6 cm. between the skin and the radium. This has proved to be very practical, although seemingly rather short. A greater distance, however, would require longer exposure of the patient, for with 6 cm. distance, an effective dose of 5,000 mg-hr. can be given in one hour, while at 8 cm. two hours is required to give 9,000 mg-hr. Both of these represent a 30 per cent erythema dose. A longer target distance increases the time quite disproportionately to the effective gain in depth dose, and thus hardly proves worthwhile.

A dose of 17,500 mg-hr. delivered in three and a half hours is equivalent to a threshold erythema. This is about 5,500 mg-hr. more than produced by similar packs of 4 grams of radium and of lesser filtration, as employed at the Memorial Hospital. We believe the extra amount of 5,500 mg-hr. delivered by the pack used at Bellevue more than compensates for the radiation absorbed by the increased filtration employed. This seems to be evidence that there must be a biological factor, too, because the shorter the wave length, the greater the proportional amount of radiation needed to make up the dose required.

Moreover, the shorter the wave length, the longer is the time required between exposure and the appearance of the erythema. Following the administration of 17,500 mg-hr. an erythema will first make its appearance in four to six weeks. This observation has been confirmed by many others and is uncontrovertable evidence that there is a different biological effect

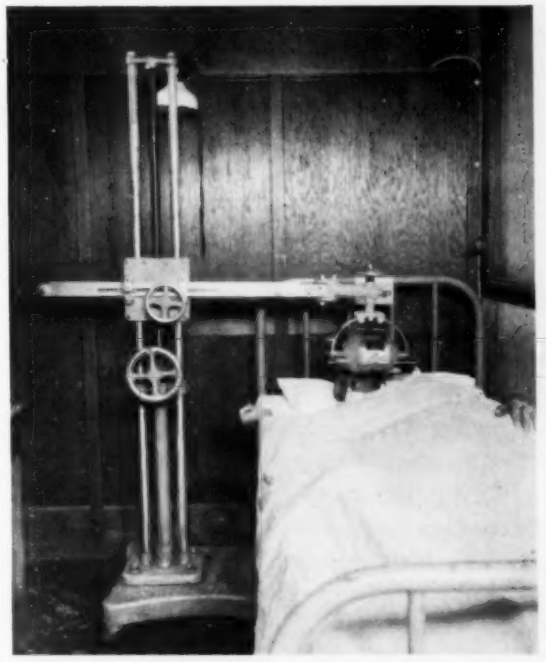

Fig. 1. The 5 gram radium pack.

with varying wave lengths. We have noted that an erythema from a single dose of the usual type of high voltage roentgen rays will appear on about the fourteenth day after exposure, reach a more fiery red color, and blanch sooner than an erythema from a single dose delivered with the 5 gram pack. The radium pack erythema dose may represent a different physical dose than that from roentgen rays but since biological effects can be studied through the medium of the skin erythema, one can see a marked variation in the character of the erythema produced by roentgen rays of varying wave lengths.

In our work with roentgen rays we have noted that the skin erythema reaches its peak in sixteen to eighteen days and then begins to subside when we employ the following factors: 200 kv., 5 ma., filter 0.5 mm. copper, 1 mm. aluminum, distance 60 cm. We have assumed this to be the optimum time duration for properly administering divided doses of protracted external irradiation which will permit complete healing after the determined dose is given. When 2 mm. of copper is used in place of the 0.5 mm. copper filter, the optimum time is twenty-one days. We have found that with the 5 gram pack this optimum time is twenty-eight days or at times somewhat longer.

As regards the depth dose, with roentgen rays filtered through 2 mm. of copper, as we employ it, the depth dose at 10 cm. is 40 per cent, while with the radium pack as described above, the depth dose at 10 cm. is only 14.2 per cent. However, measured biologically by tumor effect, the radium rays with a smaller percentage of energy, as measured by the depth dose, produce an equivalent tumor effect.

During the past year we have investigated the depth dose obtained by the 5 gram pack, using the photographic film as an indicator of the relative intensity at surface and at depth. Films were placed horizontally at various levels in a water phantom and exposed to the radium radiation for several minutes, then developed in the usual manner in the dark room with suitable check controls at every step in the process. The blackness of the exposed films, or photometric density of the films, was measured with a densitometer. The depth dose was then obtained by the ratio of the net photometric densities expressed in percentage. Preliminary measurements have been made showing that the net photometric density of the films used was proportional to the exposure, over a certain range, and the actual exposure times were selected accordingly. The results of these measurements are as follows:

5 gram radium pack: filtration, 0.5 mm. platinum plus 5 mm. lead, field, 8×10 cm., distance, 6 cm.:

Depth dose at 5 cm.	31 per cent
Depth dose at 10 cm.	14.2 per cent

Using the same factors as above, except the distance, which was changed to 8 cm. a depth dose of 39.5 per cent was obtained at 5 cm., and 18.6 per cent at 10 cm.

These measurements were later supplemented by actual tests made on the surface and in the body orifices of patients. We found, for instance, in one case that the depth dose of the uterus was 14 per cent, the uterus being 11 cm. from the surface, the dose at the cervix 35 per cent. The dose in the rectum was 10.2 per cent, with the rectum 17 cm. from the surface. These results compare favorably with those obtained in the water phantom measurements. As might be expected, the dose in the tissue is slightly higher than in the phantom.

Later, this work was carried out on patients during the course of abdominal operations. Small films, enclosed in sealed, sterilized, rubber containers were placed in various parts of the body where the intensity of radiation was of interest. At the same time a colpostat and uterine sound, loaded with radium in the usual manner, were placed in position before the abdomen was opened and the films exposed for several minutes. After removal and completed dark room procedure, the intensity of the blackness of the exposed films was again determined and the dosage determined indirectly by the photometric density of the film.

These same tests were later carried out also on a cadaver. The results in both methods were quite consistent, as follows:

	per cent
Cervix	100
Ovary	24.2
Kidney	4.0
Uterus, fundus	29.8
Middle of uterus	20.4
Parametrium	26.0
Intestines (near by)	9.45

While the most intensive dose to the cervix is given by the colpostat placed against the cervix, the dose reaching the cervix when the 5 gram pack is applied to the pelvis is also sufficient to destroy malignancy there.

Because of lack of sufficient data we are as yet unable to arrive at any definite conclusions, save that the results of measurements so far made lead us to believe our method to be practical and of value in determining the amount of radiation reaching the tissues in any given case. The figures shown are indications of the preliminary work only, which has been done so far.

For practical clinical purposes we have found it most convenient to compare the treatment of mouth and throat conditions, using the Coutard method of protracted irradiation while employing in one instance roentgen therapy and in the other gamma-ray therapy from the 5 gram pack.

With the roentgen ray, 150 r without back-scattering (our 25 per cent skin erythema dose) is given to each of two portals on the neck each day, while a 30 per cent S.E.D., or 5,000 mg-hr. of radium is administered to only one portal on one side of the neck each day. The total dose given with the radium pack is 50,000 to 65,000 mg-hr. to each portal, this being equivalent to 3 to $3\frac{3}{4}$ S.E.D. The amount of roentgen rays required to produce reactions of the same intensity when 2 mm. copper filter is used and the course of treatments is given over the same number of days is about $3\frac{3}{4}$ to 5 S.E.D. This leads us to believe that the gamma rays possess a greater biological effectiveness.

FIG. 2*a*. Skin reaction following treatment with the 5 gram pack.

FIG. 2*b*. Healed skin following treatment with the 5 gram pack.

In most instances following daily treatments with the radium pack over a period of twenty-four days and giving a total dose of 56,000 mg-hr. to each of two portals (3.2 S.E.D.) over the neck, a second degree epithelitis and epidermitis is produced on the skin and mucous membranes of the mouth. The epithelitis appears on the twelfth day and disappears on the forty-third day. The epidermitis appears on the fifteenth day and disappears on the forty-sixth day. Both of these reactions last thirty-one days (Fig. 2).

Our average of roentgen treatments by the Coutard method given over the same number of days and producing reactions apparently of the same intensity and the same duration showed that a dose of 3,200 r (without back-scattering) to each portal was required. This is equivalent to 4.3 S.E.D., and is a striking figure when compared with the 3.2 S.E.D. of the radium pack. Though these two figures might be subject to marked experimental variation and clinical error, we believe that they are still far enough apart to indicate a biological difference in the two types of rays.

In our opinion, then, the radium pack produces an effect upon the tissues and tumor similar to roentgen rays.

However, according to skin erythema dose measurements, a smaller amount of radium energy than roentgen-ray energy is required to produce this effect. Furthermore, the normal tissues are more profoundly affected by radium and are less able to tolerate subsequent interstitial irradiation than when treated with roentgen radiation.

Grade 1, with no palpable neck nodes, treatment was as follows:

Cross-fire irradiation through multiple ports producing a second degree epidermitis was administered. A small residuum of the tumor still remained after this treatment was completed, and interstitial irradiation was required (1,000 mc-hr.). Even though the dose of interstitial irradiation was small it was poorly tolerated and a persistent radium necrosis occurred which required many months to heal. We feel now

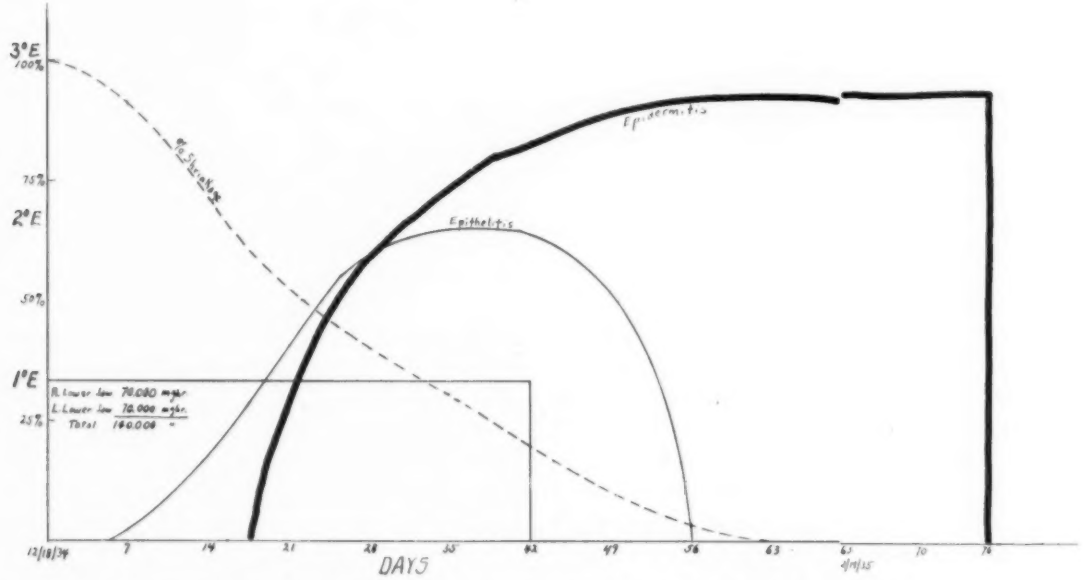

Chart 1. J. C. Cancer of the alveolar ridge. Five gram pack, 8×10 cm. portal, 6 cm. distance, 0.5 mm. platinum and 5 mm. lead filter.

Practical demonstration of the use of these modalities with comments on the results is herewith appended.

We must not overlook the fact that interstitial irradiation is a very effective method of destroying cancer, and that the average squamous cell carcinoma of low grade malignancy is radioresistant, often more so than normal skin. Selective radiation as produced by a radium pack or roentgen rays cannot destroy this type of tumor entirely. Too much external irradiation will interfere with proper interstitial irradiation. When faced with a problem such as this, wherein there is a small, early squamous cell carcinoma of the tongue, that it would have been wiser to confine the radium pack therapy to the regional lymph nodes. Then the treatment of the local lesion with seeds or needles would have been more efficiently tolerated by the tumor bed and the tongue with more comfort to the patient; the oral cavity would not have been exposed to terrific general irradiation and a much larger effective dose of external irradiation could have been given to the superficially located regional nodes which contained impalpable microscopic metastatic foci.

In giving very prolonged irradiation, as recommended most recently by Coutard, over a period of two months, it is more

effective to give treatments of the same intensity and quantity each day, rather than larger doses in the beginning and smaller ones later on.

Comparing 2 cases (Charts I and II) wherein the doses and the number of days were the same, one (Chart I) was treated with external irradiation given at a constant rate, and a severe, intense epithelitis and epidermitis was produced. The other

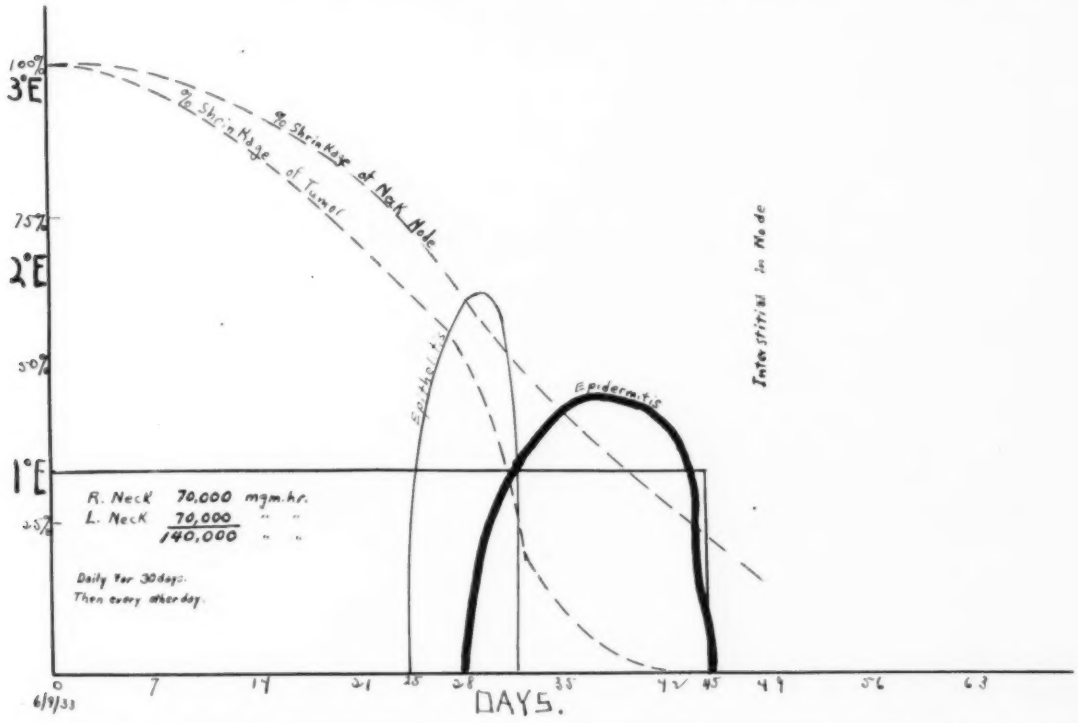

CHART II. J. R. Cancer of the hypopharynx. Five gram pack, 8×10 cm. portal, 6 cm. distance, 0.5 mm. platinum and 5 mm. lead filter.

case (Chart II) was treated with larger doses in the beginning, followed by smaller ones. There resulted a slight, short reaction which healed while the later, smaller treatments were being given. This indicates how ineffectual the later, smaller treatments must have been against a lesion rendered more radioresistant by healing fibrosis which took place after the first month of treatment.

When comparing different doses administered over the same period of time, Charts III and IV illustrate another phase of the time-intensity factor. In both cases, the reactions of epithelitis and epidermitis are similar in duration and intensity. Yet one of them (Chart III) is produced by 40,000 mg-hr. to each of two areas, administered over eight days; whereas the other is produced by 65,000 mg-hr. administered over a period of thirty-four days. One might argue that, since both skin and mucosal reactions are the same, and since these are indices of biological effect, the effect on the tumor should be the same. Experience has shown that it is not so for two reasons: first, the effect on the tumor is proportional to the total dose delivered within certain prescribed time limits; second, the biological rhythm of radiation effect is best attuned to tissue response when the radiation is delivered over a period of three to four weeks.

In a further study of the effect on tumor tissue in vivo during the course of treatment with the radium pack we have noted that this type of therapy, applied at a distance through the surface of the body

has definite destructive action on tumor tissue. Microscopic study of the irradiated cervix showed definite destruction of tumor tissue by roentgen rays and the radium pack. We conclude from this that since malignant tissue of the cervix may be destroyed by the pack, is it not reasonable to expect effective results in the parametria from the same source?

We have used the pack in pelvic conditions but so far we believe roentgen therapy to be somewhat more advisable because less time is required to give the desired dose, and the systematic reaction is more moderate.

One drawback, however, must be mentioned, namely, that as the 5 gram pack gives off constant radiation to the surrounding areas, it is necessary to provide a lead-lined room to protect those in the vicinity.

The radium dosages given with the pack are not equally distributed because the short target distance used does not allow for equalization of the dose administered to the various sections of the head and neck which exhibit inequalities of skin surface. For example, when treating a carcinoma of the larynx, the skin over the angle of the jaw may be 6 cm. from the radium source, while the skin over the larynx may be 9 to 10 cm. from the radium source, causing a marked drop in the amount of radiation administered. With roentgen therapy, the large distance from which it is administered makes such inequalities of surface of comparatively little importance.

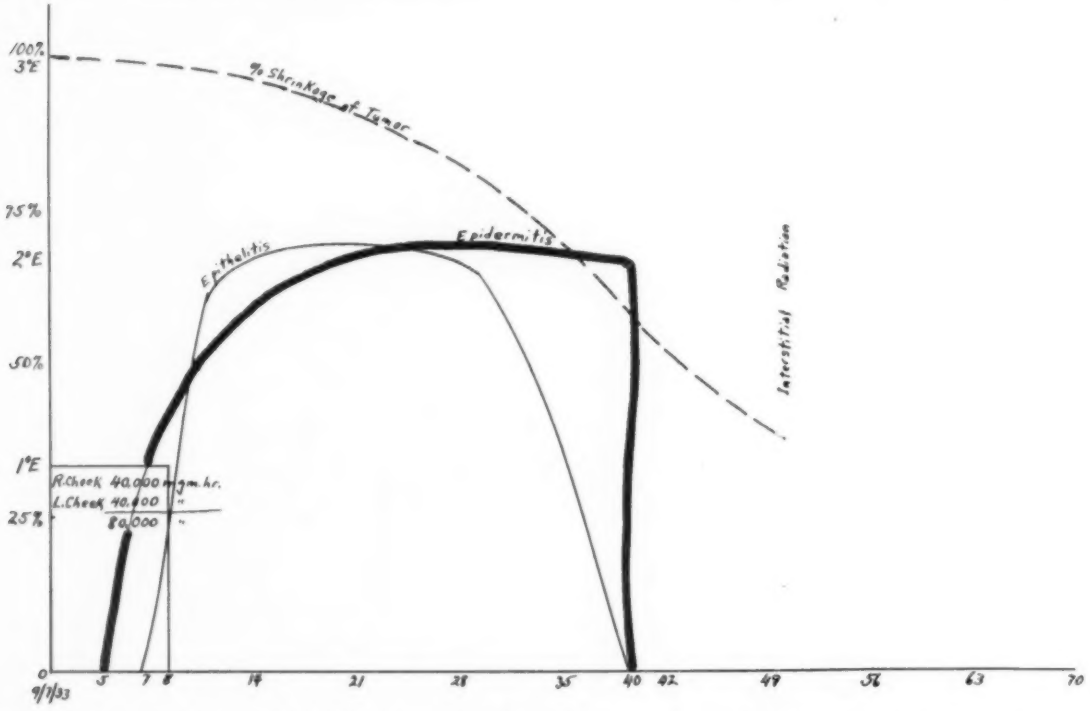

Chart III. E. R. Cancer of the cheek. Five gram pack, 8×10 cm. portal, 0.5 mm. platinum and 5 mm. lead filter.

Radium produces a profound effect on tumor bed and normal adjacent tissues so that subsequent interstitial irradiation is poorly tolerated, and there is a high incidence of slough, necrosis, osteitis and osteomyelitis. Roentgen rays do not produce such severe effects.

Radium pack therapy produces a more intense general and gastric disturbance than roentgen rays, especially when administered to the pelvis. However, radium pack therapy has these advantages: it pro-

duces a superior biological effect; a smaller quantity in terms of erythema doses is required to produce similar skin and mucosal reactions and effect on the tumor.

When radium therapy is employed the destructive phase of the incident radiation lasts from four to six weeks, and hence, in resistant lesions, treatment may be given over a longer period of time, allowing a larger total dose, before healing, fibrosis, and increased radioresistance set in.

The cervical stump was replaced by an excavated ulceration of about 4 cm. in diameter. The vesicovaginal and rectovaginal walls were infiltrated. The cul-de-sac was filled by a hard mobile mass.

Treatment. High voltage roentgen rays of 200 kv., distance 60 cm., filter 0.5 mm. Cu and 1 Al. The anterior, posterior pelvis and the perineum were treated with an open cone daily to alternate portals. Biopsy of the cervix showed the following:

Section 1. Taken at the time of beginning of

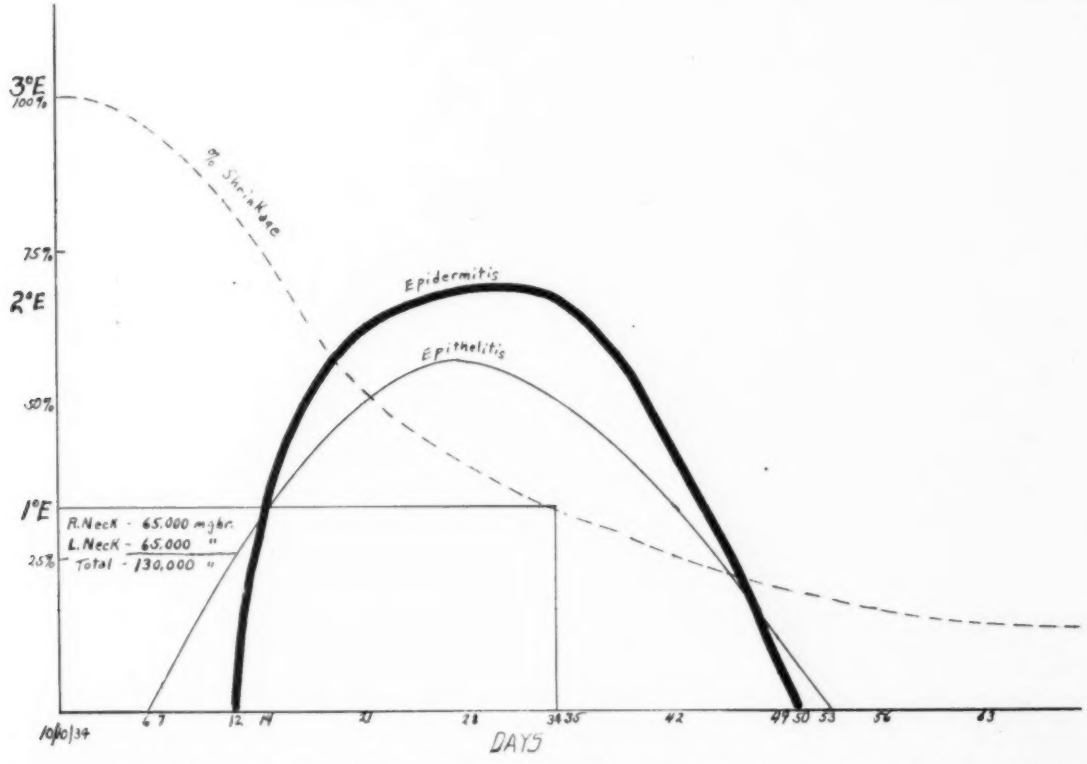

CHART IV. W. B. Van P. Cancer of a node of the neck. Five gram pack, 8×10 cm. portal, 6 cm. distance, 0.5 mm. platinum and 5 mm. lead filter.

I wish to take this opportunity to express my thanks to my staff at Bellevue Hospital who aided me materially in this work.

CASE REPORTS

Histological Changes Following Treatment with Roentgen Rays

CASE 1. Patient was forty-eight years of age, admitted because of metrorrhagia of one year's duration. Eighteen years ago, a supracervical hysterectomy was performed for profuse vaginal bleeding.

treatment. There are strands of moderately large epithelial cells placed in a slight stromal fibrous reaction. The cells are well rounded, clearly defined, and with pale staining nuclei. Keratinized pearls are in abundance.

Section 2. Taken thirty-one days after the beginning of treatment, and after a dose of 1,500 r had been administered to each of the three skin portals. The local lesion had not changed. The outstanding feature is the reaction of the epithelial cells; they are markedly swollen with very hyperchromatic nuclei. The size and shape are irregular, and frequent

mitoses are observed. Some large cells show division of the nuclei without division of the cytoplasm. The stroma shows little reaction aside from a mild proliferation of plasma cells.

Section 3. Taken thirty-seven days after the beginning of treatment, and after 1,700 r had been given to each of the three skin portals. The skin shows a second degree burn with deep pigmentation, and blistering. The vaginal mucosa has not changed. The stromal reaction has increased. Plasma cells and eosinophiles are present in moderate numbers. The epithelial cells are overwhelmingly large, deep staining and stand out distinctly in the paler staining stromal network that encircles them. The hyperchromatic nuclei show beginning vacuolization and karyorrhexis.

Section 4. Taken forty-four days after the beginning of treatment, and after 1,950 r had been administered to each of the three skin portals. The skin reaction has been aggravated; the local lesion and its extensions are slightly softer. The stromal reaction is dominant. Plasma cells, round cells, and eosinophiles appear in moderate numbers. Small nests of fibroblasts are also seen. The intima of large vessels is swollen and vacuolated, and many small vessels are occluded.

Section 5. Taken fifty-six days after the start of treatment, and after a dose of 2,000 r had been given to each of the three skin portals. The crater of the local lesion is much flatter, and the parametrial mass has softened considerably. The deeply staining malignant cells are fewer in number. Keratinized flakes of nuclear remnants are visible. The nuclei of some of the residual cells show granular and honeycombed poorly staining débris. Others show vacuoles. The strands of plasma cells have been replaced by small round cells which now dominate the stromal reaction. The section reveals fewer malignant cells, masses of round cells, and a fair degree of fibrous masses surrounding the epithelial cells.

Section 6. Taken seventy-one days after the beginning of treatment, and fifteen days after the completion of treatment. The mass in the cul-de-sac is no longer felt, and the local lesion persists as a slight residuum. The photomicrograph shows the healed area of the lesion. It appears as chronic inflammatory tissue. Round cells, lymphocytes, and an occasional plasma cell, eosinophile, and pus cell constitute the stromal network. The smaller blood vessels are entirely effaced, and the larger ones show vacuoles in the intima. The keratinized epithelial pearls have not altered, but are now surrounded by scar tissue.

Histological Changes Following Treatment with the Radium Pack

Case II. Patient was twenty-six years of age. Admitted because of vaginal bleeding of three months' duration. One year ago, a supracervical hysterectomy, with a removal of the left tube and ovary, was performed. On admission, the cervical stump was entirely eroded by a large, irregular, cauliflower mass of 6 cm. in diameter.

Treatment was carried out with the 5 gram radium pack at a distance of 6 cm., filtered through 6 mm. of lead. Three areas anteriorly, and two posteriorly were treated, giving daily treatments of two hours each, and administering one hour of 5,000 mg-hr. over each area alternately. Biopsy of cervix showed the following:

Section 1. Taken ten days after treatment started, a dose of 60,000 mg-hr. having been given to the skin over all the areas. The skin showed no reaction, but the mass was about 10 per cent smaller. Large pale staining malignant cells were present in great numbers to form the malignant mass. The few very deeply staining cells with swollen nuclei represent radium reaction. There is a strong plasma and round cell reaction. A mild vascular reaction is evident.

Section 2. Taken fifteen days after the beginning of treatment, and after a dose of 95,000 mg-hr. had been administered to the skin over all the portals. The edges of the ulceration are no longer elevated, and the red, fiery appearance has disappeared. The distinct feature at this phase is the appearance of thick strands of plasma cells which encircle the malignant cellular islands. Vascularity has increased, and areas of diapedesis are visible. The epithelial cells are swollen, but pale staining. Mitotic figures are far more numerous. The section shows an island of malignant cells, several undergoing mitosis, surrounded by clumps of plasma cells.

Section 3. Taken twenty-two days after the beginning of treatment, and after 145,000 mg-hr. had been administered to all skin portals. The skin shows a beginning erythema. The epithelial cells are large, swollen, and hyperchromatic. Increased vascularity is still pres-

ent. The section reveals a blood vessel with pronounced swelling of the endothelial cells, with slight degree of vacuolation of the cells.

Section 4. Taken thirty days after the beginning of treatment, and after a dose of 195,000 mg-hr. was given to all the skin portals. The skin shows a second degree burn with denudation. The edges of the lesion are soft and smooth, and the vaginal mucosa shows some redness. Many of the malignant cells have become smaller in size, and the deep hyperchromatism has begun to fade. Mitoses has decreased. Karyorrhexis with many bizarre nuclear formations are visible. Some of the larger nuclei have become meshed and vacuolated. The section shows the remaining huge deeply staining nuclei persisting adjacent to many plasma cells.

Section 5. Taken fifty-six days after the beginning of treatment, and eighteen days after treatment had been completed (total dose was 195,000 mg-hr.). The skin is all healed. The local lesion persists as a small ulceration. The stromal reaction dominates. It is made up of round cells, plasma cells, and some eosinophiles. There are some residual tumor cells. Although they appear darker in the field of light fibrous tissue, they are relatively much lighter than what appeared in previous sections. Occasionally, only a rim of nuclear material remains to encase a structureless nuclear residue. Many small fibrosed blood vessels are seen. The section shows the bizarre cell remains surrounded by dense stromal reaction. This approaches an abortive fibrosis.

Section 6. Taken seventy-three days after the beginning of treatment, and thirty-six days after the completion of treatment. The local lesion is arrested. There is completely scarred cervix. Several large cells persist, but appear necrotic and structureless. There is a moderate number of plasma cells, and very few eosinophiles in the mass of round cells and fibroblasts.*

* For discussion see page 517.

ADVANTAGES AND DISADVANTAGES OF THE RADIUM ELEMENT PACK*

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THE evaluation of the efficacy of a radium element pack is a most difficult task, and this task is not any less if the problem is approached on the basis of a comparison with 200 kv. roentgen rays. However, the radium element packs have been in use for some time and an effort must be made to make an estimate of what can be accomplished by their use.

The problem cannot be approached statistically, because we know that few cases of cancer which are in a curable stage are treated by external irradiation alone. These are treated by external irradiation, followed by either interstitial irradiation or surgery or both. Therefore, there is no five year result basis on which to judge radium pack efficacy. In the more advanced cases, there is no adequate statistical method to judge results. There are too many intangible variations in these cases; the following are but a few—gradation of tumor, extent of local disease, location and extent of local or distant metastases which can seldom be definitely ascertained, proximity of disease to vital structures, toxicity of the disease and the condition of the patient. Therefore, it is quite impossible to get statistical data on the advanced cases.

Clinical impression is not without importance in evaluating a method of treatment, but it is well known that the amount of weight that clinical judgment bears is proportionate to the faith the listeners have in the therapy. It is the tendency of our profession to depreciate a method of treatment if we have little or no first hand knowledge of that method.

This discussion of the radium element pack will be approached from three aspects: the physical, the mechanical and the clinical.

Physical Aspect. Under the physical aspect, it seems that the wave length must be first considered. The filter on the pack at Memorial Hospital consists of platinum and brass, arranged to be equivalent to 2 mm. of lead. The details have been given previously by Failla and will not be reviewed here. It is enough to say that the effective wave length from the radium element pack corresponds to that of highly filtered roentgen rays produced at 1,500,000 volts. If there is any differential effect of shorter waves, then the pack has the advantage, and I believe that such is the case.

The time of exposure has of late received much attention. Because of the low intensity of radiation from the pack, the duration of treatment has been relatively long. This applies not only to each exposure, but also to the number of exposures. It is customary to give exposures of two hours a day, so that it takes three days to give the usual 24,000 mg-hr. at 6 cm. distance, or six days if, for instance, both sides of the neck are treated for a total dosage of 48,000 mg-hr. To give the same relative skin dosage at 10 cm. to two opposite fields (a total of 120,000 mg-hr.) would take fifteen days, and for 15 cm., at which distance the same relative skin dosage calls for approximately twice the 10 cm. amount, thirty days of treatment are required. Therefore, the pack treatment fulfills the latter day requisite of prolonged irradiation, not only in total duration, but in duration of the individual exposure.

In the past it was thought that the tissue dosage in the tumor, no matter in what time interval it was administered, was the most important factor; therefore, massive dosage through multiple portals was

* Read in a symposium on Radium Packs at the Twentieth Annual Meeting, American Radium Society, Atlantic City, N. J., June 10–11, 1935.

used. Tissue dosage is still the most important factor and the advantage of the prolongation of the time of treatment may be due to a slower rate of recovery for tumor than for skin and other normal tissues.

The rate of recovery of tumor cells from roentgen irradiation is unknown, but we recently ascertained that the skin recovered 69 per cent of a threshold erythema produced by roentgen rays in twenty-four hours and 76 per cent in forty-eight hours, so that there is definite skin recovery between treatments. It is our opinion that less than threshold erythema recovers more rapidly than above mentioned and that greater erythema has slower recovery. We do not know the rate of recovery from radium irradiation and therefore cannot at present discuss the differential rates. The rate of recovery for radium may be delayed, possibly because of radiation effect in deeper tissue layers.

In considering the tissue dosage, it should be of interest to review briefly and comment on the work done two years ago at Memorial Hospital in comparing 200 kv. and 700 kv. roentgen rays and radium element pack.

The dosage at 200 kv. with 0.5 mm. Cu filtration at 50 cm. target skin distance was used as the norm and the threshold erythema dosage ascertained for this set-up. This was shown to be 540 r, measured in air. The 700 kv. and radium pack output was then measured electrically and also the threshold erythema ascertained. It was found that roentgen irradiation with 540 r produced the same threshold erythema as 190 minutes' exposure to the radium element pack at 6 cm. distance. This threshold erythema may be a little high, because the cases were observed for only four or five weeks and it is now thought that reactions from radium radiation appear later than from roentgen rays.* The r output measured by skin effect was 2.8 per minute at 6 cm. distance, whereas at the 10 to 15 cm. distance, it was calculated to be 1.2 and 0.57 r per minute respectively.

According to the usual small ionization chamber measurement at 6 cm. distance, the r output was between three and four times that amount or between 8.4 and 11.2 r per minute. This may be due to the difference in ionization, or it may be due to the difference in the skin effect caused by the shorter wave lengths. Granting that the second supposition holds true, it is found that we give to the skin between three and four times more radium than roentgen radiation. If there is a differential effect of radium radiation on the skin and deeper tissues, then we have gained a great deal by the use of the radium element pack.* This might be made clearer by the following example: a metastatic node in the neck is approximately 3 cm. below the skin surface. Using the usual set-up of roentgen rays, the tissue dosage at 3 cm. is 87 per cent of the skin dosage, whereas with the radium pack at 6 cm. the tissue dosage is only 50 per cent. But if the skin will tolerate three times as much radiation, then we can put three times the radium percentage dosage into the node, which, in absolute figures, is 150 per cent of the roentgen erythema dose. Of course, this depends altogether on the differential effect.

Probably the most important of the disadvantages of the radium pack is its limited applicability, not only in the number of institutions in which radium is available, but also in its limited supply in any one institution. Because of this limited amount of radium, it is necessarily used at a shorter distance than roentgen rays, and therefore the relative depth dosage is less than with roentgen rays. With very large amounts of radium the intensity of radiation would be increased so that we could use it at 20 or 25 cm. or even greater distances, thereby materially increasing the tissue dosage.

At the present time, the longest practical radium-skin distance for the pack is 15 cm. When depth dosages of the radium pack

* Recent experiments have shown that threshold skin erythemas are obtained at somewhat lower radium pack dosage than herein mentioned. These later cases have been observed over a period of six to eight weeks.

are compared with 200 kv. roentgen rays, 0.5 mm. Cu filtration and 50 cm. target skin distance, it is found that up to and including 11 cm. depth the roentgen rays give a greater percentage dosage. From a depth of 12 cm. and beyond, the radium pack at 15 cm. gives a slightly greater percentage dosage.

The constant emission of radiation from the radium pack might be considered one of its advantages, but the improvement in roentgen apparatus has made this advantage less apparent, since at the present time there are comparatively few breakdowns of roentgen machines.

Mechanical Aspect. When the radium pack is considered from a mechanical point of view, we find most of the disadvantages. In order to have a properly protected pack, it must be extremely bulky and heavy. Therefore we have considerable difficulty in applying the pack to certain regions of the body. Specifically, these regions are the cervical region in patients who have short, fat necks; the axillae in stout patients with large breasts, or in postoperative cases when the scar limits the extension of the arm; and the perineum in cases of vulval or rectal carcinoma.

In the cervical region too broad a beam of radiation would extend well beyond the limits of the disease, thereby affecting normal tissue and producing untoward local and constitutional effects. This difficulty can be overcome by increasing the distance to 10 cm. and attaching a removable cylinder which limits the beam of radiation to a small area.

The difficulty of irradiating the axilla may be overcome in many instances by the same procedure, unless the marked scarring produces complete limitation of movement of the arm.

In treating the perineum, with the patient on his side, the buttocks increase the distance of the tumor, while the radium-skin distance remains the same and therefore the tissue dosage is somewhat decreased. This can be overcome only by the method used in roentgen treatment, that of having an under-table tube. By placing the patient on the table, in a sitting posture, his weight compresses the buttocks and decreases the distance between the skin and tumor.

The time factor of radium treatment might also be classified under mechanical disadvantages. The duration of each treatment, as well as the number of treatments, is the cause of some discomfort on the part of the patient. Not only must a patient remain perfectly quiet, but it is often necessary to have the patient in an uncomfortable position. When a treatment lasts two to two and a half hours, there is an occasional complaint from the patient that the duration of the treatment becomes irksome if the position is a somewhat cramped one. This applies especially to the cervical region, when the head must be sharply rotated, or the axilla when the arm must be extended well toward the head.

If round portals are available, the total tissue absorption compared to a square portal, the side of which is equal to the diameter of the circle, is somewhat less. However, there are times when we wish to use contiguous beams of radiation. With round portals, there is likely to be some overlapping where the circumferences meet, or there is inadequate irradiation.

If the cost of radium can be included among mechanical disadvantages, I wish to dismiss this disadvantage with one statement: clinical results cannot be judged by a financial standard; so that if radium radiation gives better results, then there should be more radium procured, or means of artificial radiation devised which will approach radium in its wave length and in its efficacy.

Clinical Aspect. There are no available statistics which are adequate to prove or disprove the advantage of radium over roentgen rays. Nevertheless, repeated observations on cases treated by different types of external irradiation prove to me that better results are attained by radium packs. Again, the use of the nodes of the neck as an example will clarify the above

statement. A node which is 3 cm. below the cervical skin would receive 87 per cent of the skin dosage if 200 kv. roentgen rays were used in the usual manner, whereas the radium pack at 6 cm. distance would deliver only 50 per cent of the skin dosage at the same depth, but for equal skin effects I have noted better regression from the use of the radium pack. This must be due to the greater tolerance of the skin to gamma radiation, that is, a greater differential effect between tumor tissue and skin.

Some time ago, a series of cases of pharyngeal and laryngeal carcinoma was treated with 200 kv., 700 kv. roentgen rays and radium element pack respectively. It is too recent for comparative statistics and also the cases were too few in number, but certain clinical impressions were gained from the observation of these cases, the most important of which is that patients treated with radium element pack showed just as good immediate clinical results and these were attained with no more discomfort to the patient. This was noted especially in the effect on the skin. Another fact noted in this series was that the reaction to radium came on a little later than the roentgen reaction and was often noted on the mucosa rather than on the skin itself.

An even more recent investigation and one that should give more information is a series of 39 cases of operable carcinoma of the breast, operated upon about six weeks following completion of the radium pack cycle. Of the cases, between 80 and 90 per cent showed marked or complete clinical regression of disease at the time surgery was undertaken, and examination of the breasts that were removed showed in 28 per cent no microscopic evidence of carcinoma. All these cases had a positive biopsy before irradiation was started.

It will be some years before statistical study can be based on these cases. At least these results are encouraging and are better than have been attained by any of our roentgen procedures. A more detailed report of these cases will be given by Dr. Adair at this meeting.

Dr. Binkley favors the radium element pack in those cases of rectal cancer which offer a favorable prognosis, but hesitates to subject the more advanced and unfavorable cases to radium element pack because of the duration of treatment and especially because of the large number of trips to the hospital which are necessary to give adequate treatment at the longer radium skin distances. Dr. Craver has stated that several of his cases of Hodgkin's disease which have seemed resistant to roentgen irradiation have been susceptible to radium element pack irradiation. These cases have not been cured, but at least prolongation of life has been attained by using radium element pack treatment at a stage when ordinary roentgen therapy would have been contraindicated.

There is a very definite advantage in the use of the element pack which has been noted and mentioned previously. This is the condition of the skin at a late date, that is, several years after heavy irradiation. Although there is complete epilation, the skin is otherwise normal and lacks that brawny induration due to fibrosis so common following roentgen treatment. Telangiectases are also absent. This applies to reasonable but not to overdosage.

There is one rather distinct disadvantage to the use of radium element pack, but this can be obviated by proper care and judgment. This disadvantage is the narrow margin of safety between a sharp reaction and definite prolonged injury which is manifest by more or less permanent damage in irradiated tissue. This decrease in margin of safety between roentgen rays and radium might also be illustrated by comparison with 200 kv. roentgen rays. The threshold erythema dose, with roentgen rays, is 540 r; with the radium element pack it is 12,700 mg-hr.* If these doses are approximately doubled to 1,080 r and 24,000 mg-hr. respectively, and divided into three doses, given every second day

* Recent experiments have shown that threshold skin erythemas are obtained at somewhat lower radium pack dosage than herein mentioned. These later cases have been observed over a period of six to eight weeks.

over a period of five days, it is noted that very little skin reaction to the roentgen rays has taken place, whereas in about 50 per cent of the cases treated by the radium pack there is desquamation of the skin.

SUMMARY

In summarizing the advantages and disadvantages of the radium element pack, these more important conclusions may be stated:

(1) The wave length is that which we are trying to attain by higher voltages and heavier filters.

(2) The prolonged individual exposures and the total duration of all exposures coincide with our modern conception of protracted irradiation.

(3) The disadvantages are largely mechanical. In some cases the patient's posture during treatment is uncomfortable, but seldom sufficiently so to contraindicate the use of the pack.

(4) Statistical results are not and may never be available, but clinical impressions and judgment, which cannot be ignored, would indicate that radium pack irradiation is more efficacious than the present type of 200 kv. roentgen therapy.

(5) Since radium element is definitely limited in amount, every attempt should be made to approach, by artificial methods, the type of radiation emitted by the radium element pack.*

* For discussion see page 517.

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ADVANTAGES AND DISADVANTAGES OF RADIUM PACKS*

By BURTON T. SIMPSON, *and* MELVIN C. REINHARD
BUFFALO, NEW YORK

OUR experience with radium packs dates back fifteen years. In 1920, the Legislature appropriated money for the purchase of 2 grams of radium. This was put in solution and the radon utilized. Our first pack was a small, poorly protected radon pack amounting to about the equivalent of 1.5 grams. During the period up to 1930, improvements were made in these small packs in the line of protection and better distribution. In 1930, the Legislature again appropriated money for the purchase of radium and at this time we were able to obtain nearly 6 grams of radium salt. From this radium we constructed a 4 gram element pack which was used without modification for four years.

FOUR GRAM PACK

The 4 gram pack, with its greater flexibility of field size, treatment distances and greater radium content which obviously resulted in shorter treatment time, was a distinct advance over our previous arrangements. The results which we obtained with this pack led us to conclude that the 4 gram pack plays a definite rôle in the treatment of certain lesions; however, the results also taught us that the pack was inadequate in the treatment of other lesions.

By taking advantage of the extreme flare of the beam after it leaves the pack it is possible, due to the arrangement of the radium, to irradiate areas larger than 10×10 cm., which is the minimum field of this pack. On the other hand, in treating lesions smaller than 10×10 cm. considerable healthy tissue is irradiated. This was one of the first disadvantages we found in the 4 gram pack. Yet to reduce the field size or treatment area would be impractical and theoretically inadvisable. It was soon found necessary to supplement the 4 gram pack with auxiliary packs of smaller sizes.

Another disadvantage is that unfortunately the radiation depth intensity with gamma rays does not increase with increased treatment area as is true in the case of roentgen rays of the ordinary voltages and filtrations. Therefore, when endeavoring to irradiate a lesion at a depth there is no advantage in using the large wide-spreading beam from this pack. On the contrary, there is a decided disadvantage when cross-firing with the 4 gram pack from adjacent fields because the flare prevents close approximation of the fields. It was found that with the 4 gram pack at a radium skin distance of 10 cm., two anterior and two posterior portals could be used, provided a distance of 5 cm. was maintained between the portals on each skin surface, and that the angle did not exceed 15 degrees. This arrangement produced a depth intensity of 63 per cent at the midpoint of a pelvis of 20 cm. anteroposterior dimension. Because of the field size and the space required between adjacent fields, it was impossible to apply more than two fields with this pack to either the anterior or the posterior surfaces of such a pelvis. Two lateral portals could of course be used in addition to the two anterior and two posterior fields, but the distance from these lateral fields to the interior was too great to cause an increase sufficient to warrant their use.

Another disadvantage found in our 4 gram pack was that the surface intensity was considerably lower than in the auxiliary packs at equal distances. This is due to two factors: (1) the upright position of the radium tubes resulting in absorption of some of the radiation by the lower layers

* From the State Institute for the Study of Malignant Diseases, Buffalo, N. Y. Burton T. Simpson, M.D., Director. Read in a symposium on Radium Packs at the Twentieth Annual Meeting, American Radium Society, Atlantic City, N. J., June 10–11, 1935.

of the radium salt; (2) the distribution of the individual radium containers in the form of a hollow square.

Duplicating as far as possible conditions which exist in the 4 gram pack, measurements were made of the radium tubes when in a perpendicular position and also in a horizontal position. It was found that the intensity from tubes in the perpendicular position was 20 per cent lower, due to the filtration by the lower layers of the radium salt.

Fig. 1. View of the reconstructed three field pack.

In view of these disadvantages inherent in our all-purpose 4 gram radium pack and to a certain extent also in the auxiliary packs, we decided to turn our attention to the use of highly specialized packs each having an optimum depth intensity at a different level.

THREE SECTION PACK

Our first endeavor was the construction of a pack having its optimum depth intensity between 4 and 12 cm. This pack, containing 4.5 grams of radium, was designed to irradiate lesions in the mid-pelvic or abdominal regions only. It is based on the well-known advantage of increased depth intensity obtained by cross-firing. Three separate beams from as many independent sources of radium at a distance of 10 cm. are directed so as to begin to converge approximately 4 cm. below the skin. The beams are controlled and directed by three separate and independent sections attached to one another in such a manner that the three portals of 5.5×9.5 cm. each have their long axes parallel and separated 3 cm. The central rays of the outer sections are inclined 15 degrees from that of the middle section. The primary filtration is 1 mm. of platinum, and the secondary filtration is 1 mm. of copper and 1 mm. of aluminum. Subsequent to a series of measurements and treatments, this three independent section pack was redesigned according to the same plan except that the sections were not removable, as is shown in Figure 1.

An incident occurred during the construction of the final pack, indicating the extreme care which must be observed in the correct orientation of the beams with respect to one another as well as to the skin. In the process of reconstruction, the two outside radium trays were accidentally placed 8 mm. nearer the central tray than planned. All other conditions were the same as in the experimental pack. When measurements of surface and depth intensity were made, it was found that while the surface intensity was the same, the intensity at a depth was considerably lower. At a depth of 10 cm., there was a difference of approximately 20 per cent between the two packs. Investigation revealed that the slight shift of the radium, just mentioned, had occurred and was the cause of this difference, which disappeared when the radium was moved 8 mm. out. Were three separate set-ups required to irradiate a mid-pelvic lesion instead of one, as is the case with the three section pack, it is doubtful whether any single pack could be applied with a deviation less than 8 mm. Furthermore, the movement of the patient might be sufficient to offset any careful application of a single pack, resulting in

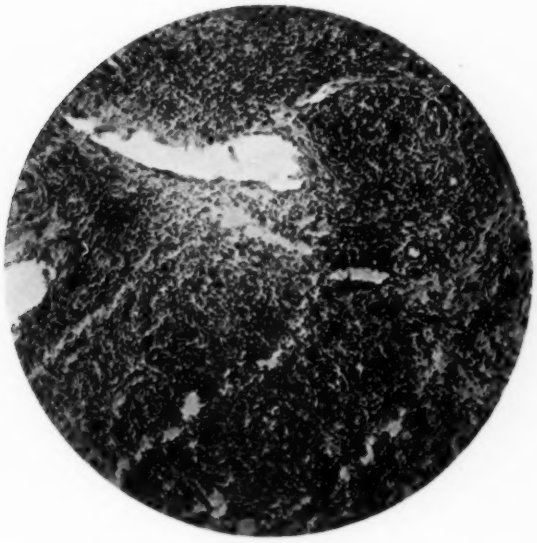

Fig. 2. Mucous membrane epithelioma of the cervix before treatment. Tumor cells stain well, show mitotic figures and malignant and invasive characteristics.

Fig. 3. Section from the same cervix as shown in Figure 2, taken one week after beginning of treatment with radium. Note vacuolization of tumor cells, karyorrhexis and variation in staining properties of tumor cells.

the tumor receiving a dose far lower than was calculated or intended.

This specialized pack has been in use for eight months in the treatment of malignancies of the bladder, rectum and uterus, and some of the results to date are very gratifying.

THERAPEUTIC METHOD

Four to five hundred roentgens per field per day are given over a period of time

Fig. 4. Cervical tissue from the same case as shown in Figures 2 and 3, taken two weeks after beginning treatment. The tumor cells are for the most part necrotic. No mitotic figures are seen. There is an overgrowth of new fibroblastic tissue.

Fig. 5. Section from the same cervix three weeks after the end of treatment shows disappearance of tumor cells. Granulation tissue, fibroblastic cells and new blood vessels have replaced the tumor.

from eighteen to twenty-five days, depending upon the thickness of the individual. The application is made alternately to the anterior and posterior surfaces. The cases selected for pure external irradiation were those which we have learned by experience do not respond to other forms of irradiation. We believe that if there is not complete disappearance of the lesion as a result of external irradiation, the remnants should be treated by interstitial irradiation. While the period is too short for definite conclusions, we have been able, however, in some advanced cases, to cause the malignant lesion to disappear as far as clinical and histological examination could determine. We would like to briefly outline the results obtained in 3 typical cases selected from a number, in which this type of irradiation has shown remarkable results.

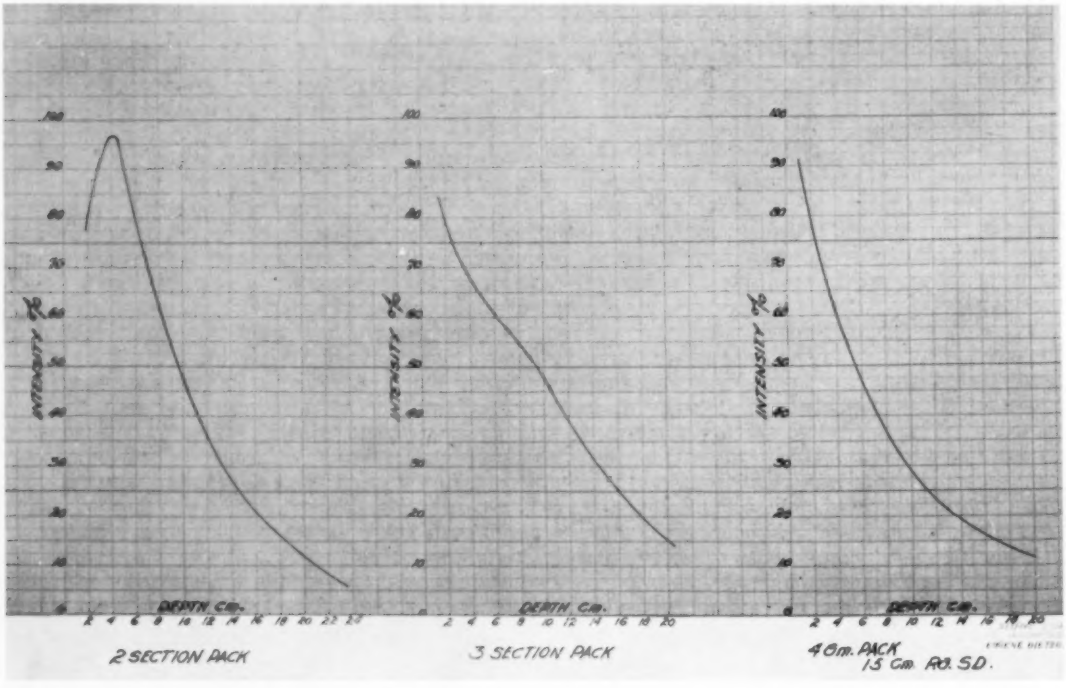

Fig. 6. Relative depth intensity curves made from measurements on the three field pack, the former 4 gram pack at 15 cm. radium skin distance, and a new two portal pack designed to irradiate lesions 2–6 cm. below the skin surface.

Case I. The patient was treated three years ago for bladder tumor. The present diagnosis, confirmed microscopically, was infiltrating carcinoma of the bladder. The three field radium pack was applied to the anterior and posterior surfaces of the pelvis, each field receiving a total dose of 6,435 r, over a period of twenty-six days. The tumor dose was 79 per cent of the surface dose. Six months after treatment there is a puckered scar in the region of the ureteral orifice, but there is no evidence of tumor and no induration in the pelvis.

Case II. Carcinoma of the cervix and infiltration of the fornices and broad ligament with fixation of the uterus. This patient received the same type of treatment for nine applications on the anterior and nine on the posterior surface, resulting in a total dose of 5,900 r and a tumor dose of 83 per cent. Six months later there was complete regression of the cervical tumor but still some thickening of the broad ligament.

Case III. There was an ulcerating indurated lesion of the rectum involving the anal ring and a carcinoma of the rectum involving the lateral wall. The biopsy showed adenocarcinoma. The three field radium pack was applied to the anterior and posterior surfaces, alternating daily for a total dose of 6,000 r to each of the six

skin areas. The tumor received 78 per cent of the skin dose. At present there is no recurrence; the patient is gaining weight and feels well, seven months after admission.

Figures 2, 3, 4, and 5 are a series of photomicrographs made from sections taken before and during the treatment as indicated, showing the progressive changes in the tumor as a result of the irradiation.

Many patients treated with this method are nauseated and depressed for the first week, after which, however, marked physical improvement is noted. The skin reaction begins to appear during the last week of treatment, progressing from red or copper color through a period of vesicle formation and desquamation, until it is at the peak about two weeks after the end of the treatment. The reaction gradually subsides in four to six weeks, the skin becoming normal.

CONCLUSIONS

1. The disadvantage of the ordinary 4 gram pack, aside from the item of expense, is its inflexibility; that is, its impracticability for treating small areas and lesions situated at various depths. This, we believe, can be obviated by specialized packs.

2. The radium pack method is time-consuming, requiring from four to five hours daily for a period of eighteen to twenty-five days.

3. It is a strenuous form of treatment and requires that the patient be in fair physical condition.

4. The intensity at a depth of 10 cm. with the multifield pack is double that of the former 4 gram pack at a radium skin distance of 10 cm.

5. The advantages may be summed up in the statement that we believe results can be obtained with specialized packs which cannot be obtained with any other type of irradiation.

DISCUSSION OF SYMPOSIUM ON RADIUM PACKS*

Dr. William H. Cameron, New York City. In 1914 I applied 700 mg. of radium on a breast, and, on the same side, 300 mg. over the supraclavicular fossa. The radium was mounted on a felt pad 1 inch thick and held in place for forty-eight hours.

The patient, aged about fifty-five, had both breasts involved; the one irradiated was large, ulcerating and the arm swollen. In three weeks, the local and general improvement was so marked that I decided to have the other breast removed. A few days after the operation the patient died.

Several months later, in a case of leukemia, I applied 1,000 mg. (twenty tubes each containing 50.0 mg. spaced 1 inch apart and mounted on a felt pad 1 inch thick) for twelve hours. There was considerable temporary improvement with no untoward symptoms.

I did not, however, have the opportunity to use large amounts of radium in a routine way until 1928 when I began to apply a 2 gram point source. To obtain an even distribution, the point source was arranged by a physicist who thoroughly understood medical irradiation problems, and feeling that it would be necessary to become thoroughly familiar with this particular point source—a technicality that must not be overlooked—the original arrangement has never been changed.

Believing that the hard gamma rays made available by this method would not be suitable for superficial skin lesions, I decided to limit my work to pelvic and chest conditions using distances ranging from 6 to 15 cm.

For several years, the clinical material was, for the most part, made up of advanced cases and this gave me the opportunity to experiment with various intensities. Intensities were gradually increased and I now find it possible to give enormous doses without injury to the skin. As a rule, these intensities are well tolerated.

I find this form of therapy of great value in the treatment (before operation or the localized application of radium) of rectal, bladder, uterine, cervical and breast carcinomas; uterine fibroids and hemorrhages; metastatic involvements and for mediastinal and large superficial tumor formations of the susceptible class.

I have been impressed with the fact that there seems to be a different biological effect from that produced by intensive roentgen rays and I am glad to hear Dr. Kaplan and Dr. Duffy confirm this observation.

I have not been able to command the clinical material reported by Drs. Kaplan, Duffy and Simpson but I have been in a position to ob-

* Papers of Drs. Kaplan, Duffy, and Simpson and Reinhard.

serve my cases carefully and for long periods, and while the treatment is rather prolonged, I do not hesitate to say that, when properly regulated for properly selected cases, deep irradiation with large amounts of radium cannot be duplicated, with safety, by other methods now in use.

Dr. Rollin H. Stevens, Detroit, Mich. I am not fortunate enough to be able to work with a large pack, so I cannot discuss these very important papers from the 4 or 5 gram pack standpoint which seem to point the way to a final solution of radiotherapy of tumors. However, I have had some experience with smaller packs of radium, containing 150 to 200 mg. I have used these packs mostly in secondary carcinoma. A number of years ago the late Dr. Arthur Heublein began some work in the Memorial Hospital on the treatment of some of the lymphomata, treating the whole patient continuously for long periods of time at a very slow rate. I was greatly impressed with the results of this treatment on one or two patients I saw at that time, cases of Hodgkin's disease that disappeared after a series of treatments. I do not know what happened to the patients later. Since then I have been trying out a modification of this treatment with radium and roentgen rays. I have used the radium at a distance of 5 cm. filtered through 4 mm. of lead together with some other material, wood or rubber, to take up the secondary radiation. I fitted a block of lead to an old roentgen tube stand, cut a deep 5 cm. slit in it, put the radium in this slit and covered it with 4 mm. of lead. I also covered the lead with wood so as to get a distance of 5 cm. when the wood was in contact with the patient. I was thus able to keep the apparatus in position for sixteen to twenty hours at a time for ten days or two weeks. Several cases of secondary carcinoma of the neck so treated cleared up and remain well for three to four years. The patient was getting a small amount of radiation in a given time but the total period was long. The radium was divided into 25 to 30 mg. lots placed 2 to 3 cm. apart. These results I think have been as favorable as any we could expect. We have been unable to treat any deep-seated lesions in this way but you have all had lesions of this kind to treat and know that they do not respond well to ordinary methods.

More recently I have used the Coutard method with 200 kv. and 2 mm. copper daily for four to six weeks; the results seem equally good. These cases have convinced me that time is the important factor. You can pour the water of Niagara Falls over a rock in an hour and see no effect whatever, but you can take the same amount of water and pour it drop by drop over a rock and wear a hole in the rock. We have records of persons being exposed constantly over long periods of time to roentgen rays and radium developing anemias, leukemias and so on from this constant exposure to radiation. We do not see such effects from large amounts in a short time. We may see some destructive lesions but not the chronic effects. I think that in radium and roentgen therapy time is the important factor.

Dr. Cameron referred to treating cancers of the rectum and seeing good results over long periods of time. I never had any satisfactory results in cancer of the rectum until this last year when I gave 2 patients a modified Coutard treatment. One was an adenocarcinoma and the other a squamous cell Grade II with proliferating lesions extending out of the anus. The latter was very resistant to roentgen therapy, but after treating these patients with small amounts of roentgen radiation, 150 r, filtered through 2 mm. of copper, daily for five to six weeks, both cases have entirely cleared up. It has been only two months since the treatment, it is true, but I have not seen such results in cases which I have treated for shorter periods of time. Sometimes I have had the idea that probably there is a selective action of radiation in the roentgen-ray and gamma-ray fields that depended upon wave lengths, but with more experience I have concluded that the result is due to time more than to selective action.

I think these papers this morning are very important contributions to the study of irradiation.

Dr. G. M. Dorrance, Philadelphia. We have not entirely paid for our radium pack so I am very much interested to know whether to continue to buy that pack or to stop with 2 grams. We are convinced that a well-equipped clinic should have a pack as well as good roentgen equipment. The size of the pack seems to be a question of style. I think every well-organized clinic should have a good-sized pack, whether 2, 4, 6 or 9 grams I do not care. We had the radium three months before the pack was properly arranged. We bought the radium and with the assistance of the Bartel Institute

we checked up and it was surprising to see how great was the variance with the way it was arranged. We are going to want that radium and we think we should have the radium. Whether it does better work than the roentgen ray I do not know. This is a critical point—often a patient will stand no more roentgen radiation; we find we can then use the pack. We found we could give more radiation in that way, or the reverse. That seems strange but I think it can be substantiated by our records. Where is surgery indicated? We have tried to check very carefully and in the very young patients on the average surgery was not worth while. It is my opinion that if you give those patients irradiation some time before operation and give an exceedingly heavy dose you will have more cases without recurrence in three to five years, and you will have more cures. In the young patients you get few cures but I think this will give a higher percentage. I do not care to operate on young breast cases without first giving irradiation. There may be an exception where you take a frozen section and establish a definite diagnosis.

I think after irradiation the breast should be removed, and then put the whole flap up. This is easy and it makes healing so much more satisfactory. I cannot determine whether roentgen rays or radium is better for these patients, but I know I would not want to be without roentgen radiation or without radium. When there is such a difference of opinion as to how to treat a superficial lesion, how much more difference there must be in regard to treating deeper lesions. We have reports of one method and of another; that is the trouble with statistics. Men have changed their methods but I think we cannot say that radium is better or that roentgen radiation is better. It is all too new and we must wait until we get a good deal more definite information about both methods so that we will be on the same standard.

Dr. Frank E. Adair, New York City. All I can discuss are the breast cases treated by the pack. We have treated about 56 carcinomas of the breast and all of them, or probably all of them, have had an aspiration biopsy which makes it possible to study these cases. If we did not have an aspiration biopsy we could not give them as much irradiation. If there is a scar, that will keep us from getting as much radiation in. We have started with about 20,000 mc-hr., using five portals, one to the supra- and infraclavicular region and one to the axilla direct. Some cases have been treated for 20,000 mc-hr. per portal, some 24,000, some 28,000. In one we got up to 24,000 mc-hr. and noticed we were beginning to get ulcers of the breast, some so painful that we had to operate to relieve the patient of pain. We had some striking results where carcinoma was treated with 20,000 mc-hr. per portal, better than with 24,000 mc-hr. for the ulcers of the breast persisted. The skin, as the dosages increased, stood it better, so I believe in the breast cases it would be better if we cut down the dosage and prolong the time. We have never had as much encouragement in the breast cases as we have had with the radium pack. Of the 39 cases examined, 11, or 28 per cent, had complete lack of any residual tumor when Dr. Ewing and Dr. Stewart cut the breast up in bits in an attempt to find residual tumor. That was not true of the axilla. The axilla is still the main problem in breast cancer. The dosages of the pack in the axilla are very different and that is something we must cope with. Eventually we may treat the breast with the pack and the axilla with high voltage roentgen therapy. To make up for this we have taken a radium string with about five silver capsules and a long uterine dressing clamp, and we make a little incision in the axilla under novocaine anesthesia. It is not necessary to use an anesthetic. As the arm is held out you can take this clamp and run behind the pectoralis major and the pectoralis minor and push it out through the pectoralis major, and then this clamp meets this radium string with the five capsules that have been placed in a rubber catheter. This is then drawn back through the axilla and left there. We started 4 cases with no radium in the catheter to discover how much damage we might have done the vein; we started with 3 s.e.d. As you cut down you find this axillary string lies behind the pectoralis major right against the axillary vein. We have done 5 cases with 5 s.e.d. and we have now 2 cases where we are giving 7 s.e.d. at the point of contact. We have operated on only 2 patients and do not know yet what we are going to accomplish. We know the irradiation must be stepped up for the axilla and we think we are on the right track. The only thing that will stop us will be interference with the brachial plexus and so far we have had no neuritis from the brachial plexus. I think we will eventually go to 10 s.e.d and if we do I think we will have accom-

plished by a comparatively simple procedure a great deal of good.

Dr. Henry Schmitz, Chicago. The discussion on the dosage and efficacy of roentgen and radium therapy has been very valuable. The essayists solved the problem very scientifically but only one just hinted at the economic aspects of distant radiation treatment and whether to use either radium or roentgen rays. There are about 150,000 new cases of carcinoma yearly in this country. If it is assumed that 30,000 patients are cured by surgery and another 30,000 by superficial radiation therapy then approximately 75,000 patients remain that are in need of deep therapy. Any solution of the problem of deep radiation therapy must include facilities for the rich and for the poor alike. With a 5 gram radium pack it is possible to treat about 300 patients a year, depending on the target skin distance. If 75,000 is divided by 300 then it is found that about 300 centers are necessary for our own country. The expense would be about $75,000,000 for 1,500 grams radium element. The output of radium a year at present is probably about 40 grams. It is inconceivable that the mines could increase the output and facilities to extract more than 100 grams yearly, though the facilities for deep radiation treatment of massive and internal cancers are needed now.

It was this thought which led my group to approach the problem by developing roentgen therapy for carcinoma patients needing distant radiation therapy. Thus the economic question could be easily solved. It has been possible to treat from 800 to 900 patients yearly by improved water-cooled cascaded Coolidge tubes, using a load of 10 to 15 ma., with from 800 to 1,000 kv.

Only 100 such centers are needed to treat all the patients with deep roentgen therapy. With the expense of constructing necessary buildings the total costs would be about $15,000,000. Any number of transformers and tubes can be built by the manufacturers as soon as needed.

The factors in production should be (1) transformers capable of developing 1,200,000 volts; (2) tubes to carry large ampere loads and voltages by water cooling; (3) flexibility in apparatus so the voltage can be changed whenever desired. It is probable that the advantages of light waves from gamma rays and ultra high voltage roentgen rays in comparison with low voltages up to 140,000 and medium voltage from 200,000 to 250,000 are entirely due to physical factors, namely, a higher formation of electrons in the depth than with lower voltages if the same skin dose has been given.

Dr. William S. Newcomet, Philadelphia. In making comparison between depth doses of roentgen rays and radium, distance must be taken into consideration. The law of "inversely as the square of the distance" is a matter of physics. The usual distance for the application of the bomb is from 10 to 15 cm. compared with the roentgen ray at 60 or 80 cm., and while the depth dose of radium and roentgen rays may be the same at the distance of 12 to 15 cm. below the skin, it must be recognized that the tissue in this area must filter out the proportional amount of radiation.

Getting a uniform field was referred to, indirectly, by Dr. Cameron, who said we had to grow accustomed to our own bomb or equipment. The reason for this is that there is a peculiar variation in the placing of the tubes. In the average bomb the tubes are placed on a flat field, in such a position that the center tubes are cross-fired by those on the sides and this, naturally, must cause some variation in the field.

Dr. George E. Pfahler, Philadelphia. I think every speaker has made a contribution and if we will analyze the discussion and the presentation of papers we will realize that we all agree and that we are all making progress. As Dr. Dorrance has so well said, we will be in position to know more about this subject in fifty or one hundred years, but that will not help us much.

Dr. Cameron has wisely said that the radiologist who is familiar with his equipment will accomplish much better results than the man who tries to adapt the other man's equipment to his work and then says it does not do as well as his own. That is the same thing as the surgeon who becomes familiar with his own tools and does excellent work but when another surgeon tries to use them he will not do as well.

I am certain in my own mind that prolonged irradiation has superior value, and whether roentgen rays or radium is used that is chiefly an economic problem so far as prolongation goes. I am thoroughly convinced that high filtration has definite value and that it will give better results in overcoming carcinoma. There again the economic problem comes into play. The greater the increase in infiltration, the

greater the expense, not only in the amount you use but in the services of the attendants. Likewise we make use of increased penetration such as Dr. Schmitz has obtained with his supervoltage equipment. How can we solve all these problems? We cannot master them all, we cannot want them all. My idea is that if each radiologist will conscientiously and accurately learn his limitations, and when he has a patient who cannot be treated with his knowledge and equipment then let him call upon a colleague who can handle that particular case. That occurs in all other branches of medicine and there is no reason why it cannot occur in radiology.

Dr. Kaplan (closing). Referring to the discussion of Dr. Dorrance, I think it is very valuable because he comes as an outside critic and brings to us his judgment based chiefly on clinical knowledge of patients, which is very valuable. Whether roentgen rays or radium, the large pack or the small pack, is applicable for all carcinomas is a question. The choice of the individual method will be governed by experienced clinical judgment, not so much what a man can do but what are his limitations which determine the method to be employed. We have used the small pack and think it excellent in the cases chosen for this type of therapy. Dr. Stevens has also shown us that he has good results with a small pack. We do not have the supervoltage roentgen machine that Dr. Schmitz uses, but we have had good results with the smaller apparatus. One of my colleagues has the supervoltage apparatus and gets some good results. However, from the clinical standpoint, when we judge our cases, we believe we get a better biological, and more clinically beneficial result from radium than we get in equally selected cases from the use of roentgen therapy. However, the therapist must know just when to use one method and when to use the other. None is a panacea but each serves a real purpose in our effort to prolong life.

NEMBUTAL IN THE TREATMENT OF RADIATION SICKNESS

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DURING the treatment of a case of carcinoma of the prostate, serious difficulty was encountered owing to severe radiation sickness. By chance, the patient, who was taking nembutal as a hypnotic, took a dose prior to receiving his daily roentgen treatment, and on this occasion the treatment was not followed by the usual nausea. The chance observation was followed up by the administration of nembutal prior to roentgen therapy in all cases showing radiation sickness.

The present paper was prepared early in 1935, based upon the result of administration of the drug to 40 consecutive cases of radiation sickness. Publication was withheld pending further investigation, but as this confirms the conclusion originally reached, we now feel satisfied that nembutal is a drug of great value in this condition.

In the beginning, its action was thought to be a specific effect, as nausea was completely prevented or controlled in all of the first patients to whom it was administered. Further experience has not supported this view but it has been found that, although the beneficial effects are very marked, they are not uniformly present and certainly not specific in the sense that in all patients the nausea and vomiting are equally controlled or to the same degree.

It was found that the symptoms were completely controlled in a majority of the cases, relief and amelioration of the severity of the distress occurred in others and there was a small percentage who were either not benefited or who were intolerant of the drug, thus making its administration impossible. It has been elsewhere reported[1] that nembutal is contraindicated in cases of liver disease and there is a small percentage of persons, probably 1 or 2 per cent, who do not tolerate barbiturate preparations. These are the only exceptions so far encountered. Of those in whom adequate doses could be given, the improvement was most marked. In at least 6 cases of the group here reported, it is doubtful if the patients could have been persuaded to continue the treatments, so severe was the radiation sickness, but by the use of nembutal it was possible to carry out the full course without undue distress (Cases 4, 6, 8, 23, 26, 37).

[1] Gillespie, R. D. On alleged dangers of barbiturates. *Lancet*, 1934, *I*, 337–345.

TIME OF ADMINISTRATION

Nembutal is best administered approximately one hour before the beginning of the treatment. In a few cases when the drug was taken within one-half hour before treatment, it seemed only to accentuate the radiation sickness. If nembutal is given more than one hour before treatment, the height of its effect has passed before the effect is most necessary.

DOSAGE

The proper dosage is gauged by first attempting to clear the symptoms by 1½ grains one hour before treatment. If unsuccessful, 3 grains before each treatment has been found to alleviate the symptoms. A certain number of patients who have had prolonged treatment have been kept under control for a short time by 1½ grains, after which 3 grains have been necessary. Thus, a satisfactory method of administration is 1½ to 3 grains, one hour before each treatment. In cases in whom severe vomiting is already present prior to the commencement of radiotherapy, so that drugs by the mouth cannot be given, suppositories of 2 grains are equally efficacious.

REPORT OF FORTY CASES IN WHICH NEMBUTAL WAS USED

Case No.	Diagnosis	Effect of Treatment before Nembutal	Effect of Treatment after Nembutal
1	Cancer of prostate, postoperative		Prolonged treatment, no nausea
2	Cancer of breast, postoperative	Severe vomiting	Vomiting ceased
3	Cancer of cervix	Nausea and vomiting	Vomiting ceased after first dose, not after third and fourth (double dose should have been tried here)
4	Cancer of right lung	Vomiting after first treatment	No vomiting since
5	Actinomycosis	Nausea and vomiting	Symptoms almost entirely disappeared
6	Malignant cystadenoma of ovaries	Severe persistent vomiting	Felt well; left hospital. Became resistant to 1½ gr. but 3 gr. each time was sufficient to control vomiting
7	Cancer of breast, postoperative	Vomited after first treatment	Settled stomach, except for train journey home
8	Embryoma	Could take only half a treatment on account of vomiting	Could take full treatment without nausea or vomiting and was able to eat every meal even though series prolonged
9	Cancer of breast, postoperative; secondary in spine and pelvis	Severe vomiting for two days; no appetite	No vomiting; ate all meals; after six treatments began vomiting again (double dose should have been tried here)
10	Sarcoma right lung; lymphatic leukemia	Vomiting after first treatment	Took nembutal for two days; was not nauseated for the rest of first series; for next series of treatments refused to take nembutal
11	Fibroid uterus	1½ gr. before moderately severe treatment	No nausea, but lack of appetite
12	Cancer of uterus, postoperative	Severe nausea and vomiting and loss of appetite	Progressive improvement; after two doses felt perfectly well
13	Retroperitoneal sarcoma (pelvis)	Severe and extreme nausea; sometimes vomiting	Felt better after first capsule; perfectly well since
14	Cancer of cervix	Extreme nausea and vomiting	Only temporarily relieved by one capsule (3 gr. should have been indicated here)
15	Cancer of breast, postoperative	After 4th treatment took 1½ gr. nembutal after being sick for two days	Very ill for two weeks after one dose of nembutal; idiosyncrasy
16	Ewing's sarcoma of right ilium	Nausea and vomiting; given ¾ gr. daily	Made her feel better, but slightly dizzy; ¾ gr. was sufficient throughout long series
17	Cancer of body of uterus	Severe nausea and vomiting	Still slightly nauseated, but vomiting ceased after 1½ gr. nembutal
18	Hemangioma of mediastinum	Severe nausea but no vomiting	Stopped extreme nausea
19	Cancer of body of uterus	Loss of appetite; nausea and vomiting	Ceased vomiting and settled stomach; appetite returned
20	Cancer of tongue; secondary in neck	Loss of appetite; nausea and vomiting	Symptoms relieved
21	Parotid tumor	Nausea and headache	Symptoms relieved
22	Cancer of breast, postoperative; recurrent	Nausea and vomiting	Was able to finish series of treatments without any nausea after nembutal

REPORT OF FORTY CASES IN WHICH NEMBUTAL WAS USED (*cont.*)

Case No.	Diagnosis	Effect of Treatment before Nembutal	Effect of Treatment after Nembutal
23	Cancer of cervix	Extreme nausea and vomiting	After two administrations no nausea, later 3 gr. nembutal necessary and finally the associated hydrochloric acid treatment was also necessary
24	Fibroid uterus	Nausea and vomiting	Symptoms relieved
25	Menorrhagia	Nausea and vomiting	Much less nausea and no vomiting
26	Lymphosarcoma of mesenteric glands	Extreme nausea and vomiting	After 1½ gr. little effect; after 3 gr. nausea relieved; later hydrochloric acid necessary
27	Cancer of breast, postoperative, recurrent	Nausea and vomiting	Symptoms relieved
28	Cancer of breast, postoperative	Nausea and vomiting	Drug made her dizzy, but relieved her nausea and vomiting
29	Cancer of bladder	Nausea and vomiting	After 1 capsule per day nausea and vomiting ceased
30	Hodgkin's disease	Nausea and vomiting	After 1½ gr. nembutal symptoms not relieved; 3 gr. relieved symptoms
31	Cancer of breast, postoperative	Extremely nauseated, but could not vomit	Nausea relieved
32	Malignant cystadenoma of ovary	Severe nausea and vomiting	1½ gr. nembutal before each treatment, combined with 5 drops HCl before each meal, kept this patient free of nausea throughout long series of treatments
33	Cancer of body of uterus, recurrent	Nausea and vomiting	Symptoms relieved
34	Abdominal Hodgkin's disease	Severe nausea and vomiting	Symptoms relieved, 2nd series; extreme nausea and vomiting during entire first series
35	Cancer of left abdomen, recurrent	Severe nausea and vomiting	Nausea and vomiting ceased
36	Cancer of bladder	Extremely sick and weak	Had to stop treatments for two days on account of severe nausea and vomiting then 3 gr. necessary along with HCl before meals, but was able to finish series comfortably
37	Cancer of cervix; secondary cancer of vagina	Nausea and vomiting two weeks before treatments	After first dose of nembutal felt much better than she had for three weeks
38	Cancer of breast, postoperative; secondary cancer, lung and spine	Took nembutal from beginning prophylactically	Was not disturbed by treatments
39	Hypernephroma, postoperative, metastatic	Treated for one month three months previously with severe radiation sickness	Second series (teleradium) was given with very little sickness after administering 1½ gr. nembutal before each treatment; was able to drive in each day for treatment
40	Cancer of cervix	Nausea and slight vomiting	Nausea almost entirely cleared

SUSCEPTIBILITY

In our experience only 1 out of 40 cases treated has had an idiosyncrasy to nembutal. This patient was ill for two weeks following one dose. Her idiosyncrasy to the drug was confirmed by the fact that she had a similar experience following the administration of nembutal preoperatively.

This patient had no evident liver damage and the undesirable effect seemed to be a true instance of idiosyncrasy.

DURATION OF EFFECT AND ASSOCIATED TREATMENT

Four of the 40 cases (Cases 26, 23, 36 and 32) who received a prolonged series of treatment and who, after two to three weeks of daily treatments, even with 3 grains of nembutal before each treatment, began to develop a resistance to the drug, have been greatly assisted by the administration of 5 drops of hydrochloric acid before each meal. In other cases, also, hydrochloric acid has assisted in bringing back to normal almost immediately the patient's appetite on the completion of a series of treatments, the function of the secretory system of the intestinal tract having been disturbed by irradiation, or reduced by the frequent vomiting, thus depleting the hydrochloric acid content of the gastric secretion.

A SURVEY OF CHEST ROENTGENOGRAPHIC TECHNIQUE*

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IT IS generally admitted that chest roentgenograms must be comparable if accurate diagnosis and treatment of chest diseases are to be accomplished. The task of prescribing methods for the production of comparable chest roentgenograms is complicated. Any attempt to study this problem requires careful analysis of the apparatus and technique used for producing the roentgenograms and for observing the finished films. Furthermore, it is necessary to analyze the types of chest films used in institutions at the present time, since any attempt to render these films comparable must be based upon changes in the present methods.

It is the purpose of this paper to present data concerning the qualities of chest roentgenograms used in a number of institutions throughout eastern United States and Canada.

Before presenting the data of the survey the general plan for the study of apparatus and technique is outlined, and the physical tests used for the survey are described.

General Plan for the Investigation of Chest Roentgenographic Apparatus and Technique. The study of the electrical and physical problems of chest roentgenography for the purpose of improving and standardizing clinical results may be advantageously divided for discussion as follows:

1. The results of carefully controlled tests of the apparatus used for chest roentgenography (referred to below as "apparatus tests").

2. Comparable data showing what technical methods are used in clinical practice (referred to below as "survey of clinical technique").

3. The scientific choice and correlation of optimum values of technical factors for producing chest roentgenograms of the greatest possible diagnostic value (referred to below as "standardization of technique").

4. The development of methods for specifying, reproducing and improving the techniques derived from (3) (referred to below as "improvement of technique").

The high voltage generating apparatus and auxiliary materials used for chest roentgenography have been tested. Some of the methods have been described.[1,2,3,4,5] The publications of other workers in this field have been carefully consulted.† The results of these apparatus tests form the basis upon which the methods for the standardization and improvement of technique must be constructed if these methods are to be of practical value. The limitations of the apparatus available for chest roentgenography determine important compromises in technical methods.[7,8,9] A detailed discussion of the important types of roentgenographic apparatus and of the criteria by which equipment should be chosen for chest roentgenography is given in a book recently published.[6]

Roentgenographic Method for Comparing the Techniques Used at Different Institutions. The data presented in the next section were recorded during a general test survey of the apparatus and technique used at twenty-nine sanatoria throughout eastern United States and Canada. A reproducible method was chosen for the comparison of roentgenographic results. An aluminum ladder was chosen as test

† The works of the following have proved particularly important: Bouwers, Clarke, Gross, Swindells, Taylor, Terrill and Ulrey, S. L. Warren and Bishop, and Wilsey.

* The survey described in this paper was conducted as a part of a project at the University of Pennsylvania, under a grant by the National Tuberculosis Association. The work is directed by Dr. F. Maurice McPhedran of the Henry Phipps Institute and Charles Weyl of the Moore School of Electrical Engineering.

object because it was small, convenient to roentgenograph, and constant in roentgen-ray absorption characteristics. The ladder, with ten steps of $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, . . . $1\frac{1}{4}$ inch thickness, was used for all of the tests described below. The results of the tests described below showed that an analysis of ladder roentgenograms made with several techniques provided a means of predicting the density and contrast characteristics of roentgenograms of a chest made with the same techniques. In order to substitute the ladder for the chest it was necessary to show that there was equivalence between the densities of parts of roentgenograms of the two objects made with the same technique. For this purpose nine roentgenograms of the type shown in Figure 1 were made with a four valve apparatus, with synchronous (impulse) timer. The focal spot-film distance for all films was 4 feet; the roentgen tube current was 100 ma. The same cassette and intensifying screens were used for all roentgenograms. The chest of the subject of these tests was considered average for male adults, the posteroanterior chest diameter being approximately 21 cm. The roentgen tube peak voltages and the exposure times for each of the nine exposures are listed in Table 1.

TABLE I

Roentgenogram	Roentgen Tube Voltage kv. (peak)	Exposure Time	
		Seconds	Half cycles
1	67	1/10	12
2	72	1/10	12
3	62	1/10	12
4	62	7/60	14
5	67	7/60	14
6	72	7/60	14
7	72	1/12	10
8	67	1/12	10
9	62	1/12	10

A preliminary series of films showed that the technique of roentgenogram 1, Table 1, produced a diagnostically useful film.* The remaining techniques 2–9 were chosen to obtain densities and contrasts greater and less than those of the chosen standard. The subject was carefully oriented in the same manner for each of the nine roentgenograms. The films were developed simultaneously. After processing, the area *within the chest shadow* was scanned with a photoelectric densitometer to find the points of minimum density

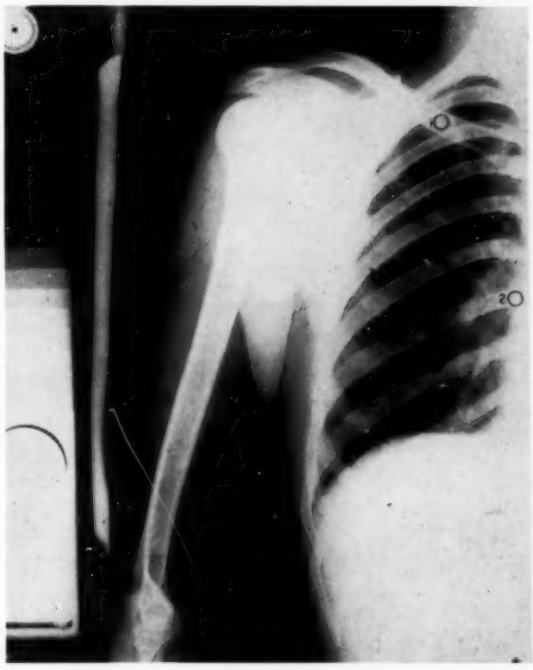

FIG. 1. Roentgenogram of half-chest and aluminum ladder made simultaneously. The marked areas are those of minimum density (areas 1 and 2), maximum density (area 4) and average density (area 3) *within the chest shadow.*

(areas 1 and 2, Fig. 1), maximum density (area 4, Fig. 1) and average density (area 3, Fig. 1). These points were marked as shown in Figure 1. The four areas of the shadows of the same lung parts were marked in each of the remaining eight films. The roentgenographic densities of the thirty-six areas thus specified were measured with the densitometer. The densities of each step of the aluminum ladder roentgenograms were measured, and nine curves, of which Figure 2 is an

* It is irrelevant to the purpose of this paper to discuss the relative merits of the nine films. Such discussion is reserved for consideration in papers dealing with the standardization and improvement of technique.

example, were drawn. Figure 2 shows the variation of roentgenographic density with thickness of aluminum for the roentgenogram shown in Figure 1. The densities of

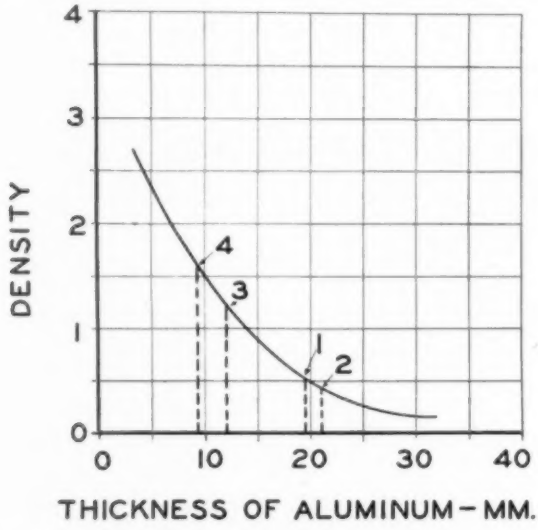

Fig. 2. Curve showing variation of roentgenographic density with thickness of aluminum for the roentgenogram of Figure 1. The four points marked and numbered indicate the densities and equivalent aluminum thicknesses of the chest areas marked 1, 2, 3, 4 in Figure 1.

the areas marked in the lung shadow of Figure 1 were:

Table II

Area in Lung Shadow	Density
1	0.52
2	0.42
3	1.21
4	1.61

From the curve (Fig. 2) it was found that, in this particular roentgenogram, the density in the film under 21.5 mm. of aluminum would have been the same as the density of area 2 in the lung field. Therefore this thickness of 21.5 mm. of aluminum was defined as the thickness equivalent to the lung tissue which absorbed and scattered the primary radiation contributing to the density of area 2 of the lung field. In a similar manner the equivalent thickness for areas 3 and 4 of the lung shadow were found to be 12.0 mm. and 9.3 mm. of aluminum respectively. The data for area 1 were nearly equal to those for area 2, so that it was unnecessary to carry through the analysis of area 1. The equivalent thicknesses are marked by vertical dotted lines in Figure 2 and numbered to correspond to the lung areas of Figure 1.

The equivalent thicknesses of aluminum were obtained for each marked lung area in each film. Figure 3 is a graphic representation of the nine equivalent thicknesses of aluminum obtained for each of the lung areas 2, 3, 4. The actual film densities for areas 2, 3, 4 extended between the following extremes:

Table III

Roentgenogram	Density for Lung Area Number		
	2	3	4
9	0.16	0.45	0.74
6	0.71	1.53	1.95

It was concluded from the data shown graphically in Figure 3, and the data of Table III that the aluminum ladder might be used as standard, since for any chest

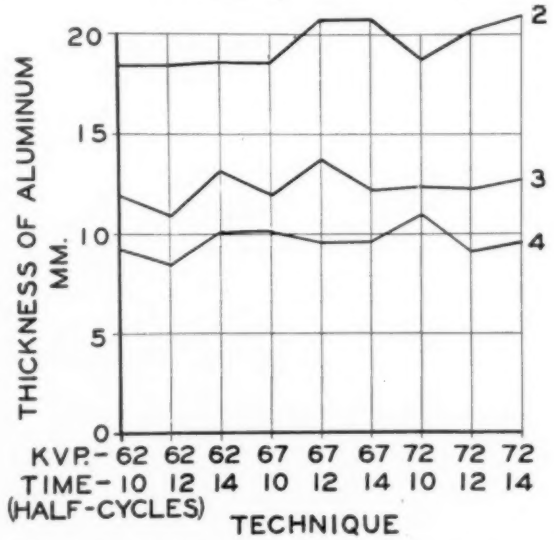

Fig. 3. Graphic representation of the variation of equivalent aluminum thickness with technique for the chest areas 2, 3, 4 of Figure 1. The equivalent aluminum thicknesses for area 1 were so nearly equal to those for area 2 that it was unnecessary to consider them.

area the equivalent thickness of aluminum had an average deviation from the arithmetic mean of 5.2 per cent or less. Since the individual deviations were so small and apparently random (see Fig. 3), it was concluded that these deviations were caused by experimental difficulties in maintaining the proper position of the patient for the nine roentgenograms, in producing the same conditions of respiration and in marking the areas 2, 3 and 4 in the nine films.

A roentgenogram of the aluminum ladder, made at a technique chosen by a particular roentgenologist for the chest of an average adult, might be compared with other ladder roentgenograms made at other laboratories to determine what qualities of chest films were produced in routine clinical practice.

The Quality of Chest Roentgenograms Chosen by Twenty-Nine Sanatorium Roentgenologists. During 1933–1934 the roentgen laboratories of twenty-nine tuberculosis sanatoria were visited for the purpose of testing roentgenographic apparatus and of discussing with roentgenologists some of the electrical and physical problems associated with its use. A comparative study of the qualities of chest roentgenograms of an average adult made at the sanatoria was based upon the tests described below.

The roentgenologist was asked to make a roentgenogram of the ladder, using his film, intensifying screens, roentgen apparatus and dark room equipment. He chose a technique which, in his estimation, was correct for an average adult male patient for whom it was desired to obtain a film to demonstrate minimal tuberculous lesions throughout the lung. The roentgenologist made all of the adjustments of his apparatus and directed the making of the roentgenogram. It was developed in his dark room in accordance with his standard procedure. After the film was processed the densities of each roentgenogram were measured with a photoelectric densitometer. This procedure was repeated in each of the twenty-nine sanatoria.

Curves showing variation of density with thickness of aluminum, like the one shown in Figure 2, should be, within the limits described in the preceding section, representative of the technique used at a particular sanatorium. A collection of curves for all of the sanatoria plotted on the same sheet demonstrates clearly the differences in technical methods which it is the purpose of this paper to describe.

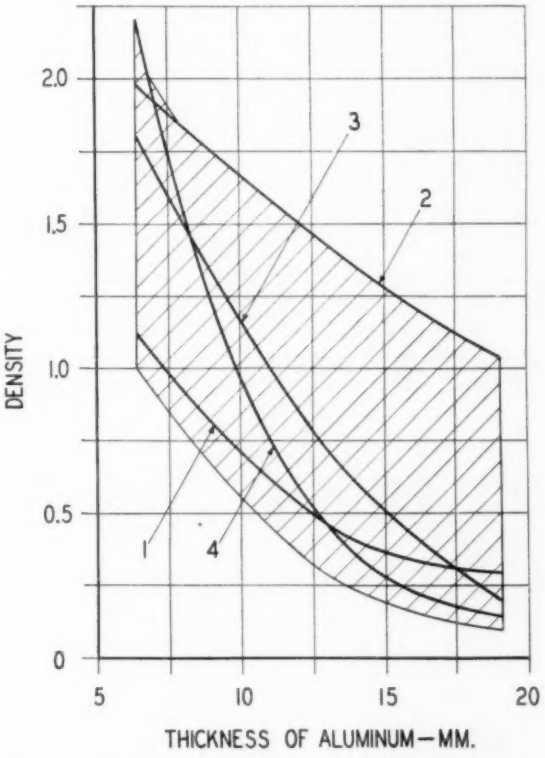

Fig. 4. Graphic indication of the variation of technique among the sanatoria. Curves showing variation of density with thickness of aluminum for all of the sanatoria are found to be distributed throughout the shaded area. To avoid confusion only four curves, typical of the group, are reproduced.

Since reproduction of the entire twenty-nine curves becomes confusing, Figure 4 simply indicates the limits of the group and shows four typical curves. The remaining twenty-five curves are distributed throughout the shaded area.

The type of apparatus and the various technical factors, such as tube current, tube voltage, etc., were recorded at the

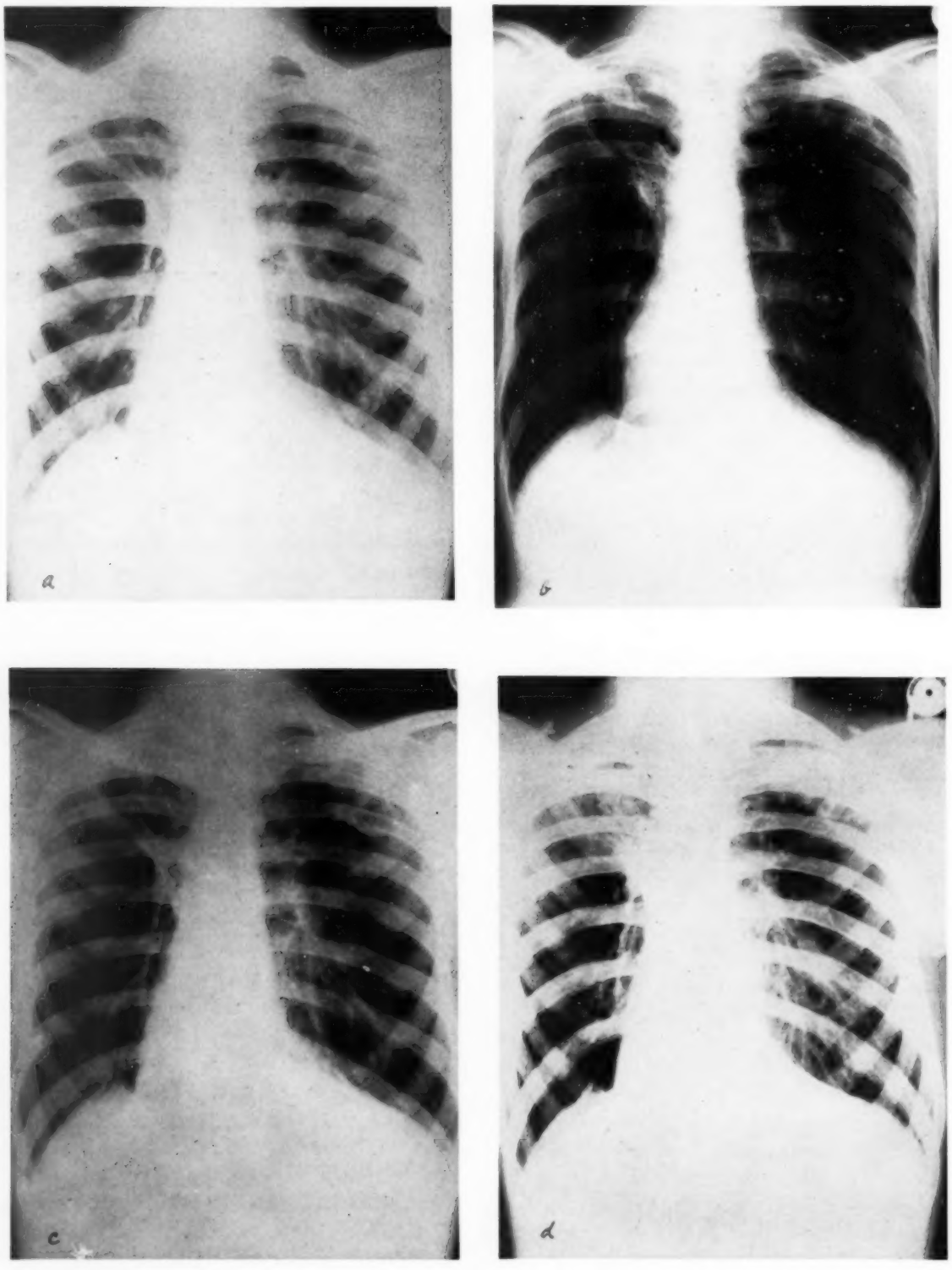

Fig. 5. Four roentgenograms of the chest made at techniques similar to those represented by the four curves in Figure 4: *a* corresponds to Curve 1; *b* corresponds to Curve 2; *c* corresponds to Curve 3; *d* corresponds to Curve 4.

same time. These data are discussed in the last section of the paper.

First, certain qualitative correlations may be made. There are shown in Figure 5, reproductions of four roentgenograms of the chest. Figure 5*a* is a roentgenogram made with a technique the same as that for which the curve marked 1 in Figure 4 was made. Similarly, Figure 5*b* corresponds to Curve 2; Figure 5*c* corresponds to Curve 3, and Figure 5*d* corresponds to Curve 4. These four roentgenograms permit a qualitative analysis of the defects of the techniques used in the sanatoria. The roentgenogram, Figure 5*a*, was obviously underexposed. It is impossible to distinguish small shadow differences throughout the entire lung area. Such a technique is not to be recommended. Figure 5*b* represents a film which has been greatly overexposed so that with the average viewing box the eye does not see shadow differences in any but the least dense portions of the film. Figure 5*c* represents a film useful for diagnosis. It will be noted that small shadow differences are visible *throughout the lung area*. All areas of the film have densities which are neither too high nor too low for clear perception when used with a good film illuminator. Figure 5*d* shows a film of a type which has definite disadvantages, although many roentgenologists have chosen to use such films during the past few years. When relatively high power roentgen equipment became available it was the tendency to overemphasize the high contrast roentgenograms which could be made with these powerful machines. Certain areas in Figure 5*d*, particularly those under the lung apices, and those near the periphery at the base of the lung, have correct densities and very high contrast. However, a great part of the lung shadow is characterized by very low density. Due to fog, and to density-exposure characteristics of roentgen film for small exposures,[10] the contrast within these lower densities is insufficient. As a result, the diagnostic quality of a few parts of the film is improved. The diagnostic quality of the remainder is inadequate. If the roentgenologist determines to seek maximum contrast in a particular area so that films of the type of which Figure 5*d* is an example are produced, it will be necessary to make more than one roentgenogram of each chest in order to avoid leaving parts of the thorax unstudied.

The data presented above are interesting chiefly because they demonstrate the great differences in technique used by a group of men who pay special attention to the improvement of technique. These great differences are apparently due to two factors. In the first place, the physical characteristics of a useful roentgenogram have not been carefully analyzed and presented to the roentgenologist in understandable form. Second, once a roentgenologist has used a particular type of film for a long period it is difficult for him to appreciate the value of films with different quality. It is not the purpose of this paper to discuss possible solutions for these two important problems. Work which is now in progress will lead, it is hoped, to such solutions.

The Apparatus and Technical Methods used for Chest Roentgenography in Twenty-nine Sanatoria

The following presents in summary form the types of apparatus and the technical methods used in the sanatoria included in this survey.

Classification of the patient. The following methods of classifying the patient were found to be commonly used:

1. The technician estimated the chest diameter and the muscular structure of the patient, and chose the technique by applying these qualitative data and the knowledge he had gained by experience. When the technician understood the characteristics of the roentgenographic apparatus and materials, and, when by experience, he had acquired an intuitive method for judging the patient, the results were found to be satisfactory, although the technician had no way of explaining quantitatively

how he made the roentgenograms. In the great majority of cases where this method was used the results were poor. In any case, in the absence of the technician, there was no way for a substitute to continue the work in a comparable manner.

2. The patient was placed before the cassette holder and the chest diameter was measured by means of an L-shaped rule, one side of which was perpendicular to the cassette front, the other side, pressed against the patient's back, parallel to the cassette front. Several modifications of this method were also found. The patient was in some cases bound to the cassette holder by means of a cotton band before measurement; in others, a straight rule was held perpendicular to the cassette front, the technician sighting along the back of the patient to a point on the rule. In a few cases care was taken to make the measurement under definite conditions of the respiratory phase. In general, the chest diameter measurement alone was used to determine the roentgenographic technique; in some cases the method included an estimate of the muscular structure of the patient.

3. The chest diameter was measured by means of a pelvimeter. In general, the patient was measured while relaxed and breathing normally. A few technicians estimated the muscular structure of the patients and combined this estimate with the chest diameter measurement to form the basis for the choice of technique.

The type and capacity of high voltage generating apparatus. The following types of apparatus were used:

1. Mechanically rectified apparatus, capacity 100 kv. (peak), 30 to 200 ma. (14 sanatoria).

2. Mechanically rectified apparatus, capacity 100 kv. (peak), 200 to 500 ma. (5 sanatoria).

3. Single valve, half-wave rectified apparatus, capacity 100 kv. (peak), 100 ma. (1 sanatorium).

4. Four-valve full-wave rectified apparatus, capacity 100 kv. (peak), 250 to 500 ma. (3 sanatoria).

5. Four-valve, full-wave rectified apparatus, capacity 90 kv. (peak), 1,000 ma. (2 sanatoria).

6. Six-valve, three-phase, full-wave rectified apparatus, capacity 90 kv. (peak), 1,000 ma. (1 sanatorium).

7. Condenser discharge apparatus (3 sanatoria).

The focal spot-film distance. Focal spot-film distances used in the various institutions varied from 1 meter (3.3 feet) to 2.4 meters (8 feet). In the majority of cases the focal spot-film distance was not chosen with due consideration to the electrical capacity of the high voltage generating equipment.

The exposure time. Exposure times were chosen for these tests varying from 1/60 to $\frac{5}{8}$ second. Synchronous impulse timers were used at eight sanatoria.

Roentgen tube peak voltage. As is shown by the differences in contrast in the curves of Figure 4 the roentgen tube peak voltages chosen for these tests by the roentgenologists varied over wide limits. The minimum voltage was 53 kv. (peak), the maximum voltage 93 kv. (peak). It should be noted that the specification of roentgen tube peak voltage does not determine definitely the quality of the roentgen beam, since the wave forms of high voltage generators may differ considerably. In particular, the wave form of condenser discharge apparatus is quite different from that of the remaining types of equipment described above. Therefore, although the contrast curves for condenser discharge apparatus are included in the shaded area of Figure 4, the data for roentgen tube voltage, tube current and exposure time are not included in this section.

Roentgen tube current. Tube currents from 30 to 1,000 ma. were used for this test.

Film developing time and temperature. In the majority of institutions the technician claimed that a time-temperature method of developing was used. Since in some cases the apparatus could not be accurately con-

trolled it is believed that developing procedure was carried out by examining the film at various times until it appeared under the illumination of a safe light to have sufficient density. No electric refrigerators were used, although it was necessary to use ice to help cool the solutions. The temperatures of the solutions varied from 17.8°C. (64°F.) to 25.4°C. (78°F.). In a few cases automatic valves were used in winter to mix hot and cold water in the proper proportions to maintain the correct temperature. More often this was accomplished by manual adjustment. Five gallons of developer (the quantity used almost universally) were used to process from 72 to 250—35.6 by 42.3 cm. (14 by 17 in.) films, the time usually being changed arbitrarily as the developer aged. In two cases the developer was carefully calibrated and the developing time changed accordingly.

CONCLUSIONS

The standardization and improvement of technique, mentioned in the first section of this paper, require the data presented herein for useful solution. Criticism of the apparatus and methods used will be reserved for subsequent papers discussing these important items.

The data demonstrate clearly:

1. The qualities of chest roentgenograms made in different institutions are so different that no comparable diagnostic data can be exchanged.

2. The qualities of film obtained in any one sanatorium vary considerably from time to time.

3. Any method for the scientific choice and correlation of optimum values of technical factors for producing chest roentgenograms must take into account the large expenditures already made by institutions for roentgen apparatus.

4. Any methods for standardizing chest roentgenographic procedure must allow for specification, reproduction and improvement of the techniques so derived.

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THE CHOICE OF CERTAIN TECHNICAL FACTORS FOR CHEST ROENTGENOGRAPHY*

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IN GENERAL, the roentgenograms of the chests of average adults, taken in the same laboratory at different times, or in different laboratories, do not conform to a standard of roentgenographic quality. This is due, in part, to the fact that each roentgenologist chooses the technical factors for chest roentgenography in his laboratory in such a way that the films satisfy his personal judgment. There is no tendency for agreement between the judgments of a number of roentgenologists. Any attempt to maintain a standard is compromised by the fact that the roentgenologist and technician do not have the opportunity to study in detail the physical basis upon which chest roentgenography has been developed.

A brief description of these technical factors, and a scientific choice of these factors, will aid the roentgenologist and technician in their attempts to approach and maintain a reasonable standard of quality for chest roentgenograms.†

This paper therefore summarizes methods recommended for the production of roentgenograms of the chests of average adult patients. For detailed analysis concerning the choice of some of the factors references are given at the end of the paper.

The Choice of the Optimum Characteristics for the Finished Roentgenogram. No generally accepted choice of optimum characteristics for a roentgenogram of the chest has been developed upon a scientific basis. Roentgenologists are prone to make films of a particular quality chosen by habit, without regard to the physical characteristics of films and to the visual characteristics upon which diagnosis depends. The different appearances of films of similar patients, made in different laboratories, demonstrates this personal influence.

In spite of the prevalence of the rule-of-thumb method, the choice of technical factors for roentgenography can be made upon a scientific basis. If the density‡ within the shadow of the chest is less than about 0.40 the contrast decreases rapidly with a decrease in density due to the characteristics of films and intensifying screens. Therefore, if chest roentgenograms are made with densities within the diagnostic area less than 0.40, and if areas of this density are observed for the purpose of diagnosis, the optimum perception of shadows of diagnostic interest cannot be attained. The normal visual characteristics are such that the eye is most sensitive to small differences in density over a wide range.[4] There is, however, an upper limit to this ability to perceive small density differences. This upper limit of density depends, in part, upon the intensity of the light from the viewing device, by the aid of which the roentgenogram is observed. With due consideration to the light intensities normally used in modern viewing devices, this upper limit of density may be fixed at about 1.50. In other words, visual characteristics require that the maximum density within the diagnostic area of a roentgenogram does not exceed 1.50.

† It should be recognized that some of the factors normally used to specify roentgenographic technique are not the fundamental factors for this purpose from a scientific point of view. Nevertheless, the first approach to the problem should include only a discussion of the factors with which the roentgenologist and technician are now familiar.

‡ The roentgenographic density of an area of a finished roentgenogram is defined as the logarithm to the base 10 of the ratio of the intensity of the light incident upon the area to the intensity of the light transmitted by the area. Roentgenographic contrast between two areas of a finished roentgenogram is defined as the difference of the densities of the two areas.

* The recommendations contained in this paper are based upon data obtained at the University of Pennsylvania under a grant by the National Tuberculosis Association. The work is directed by Dr. F. Maurice McPhedran of the Henry Phipps Institute and Charles Weyl of the Moore School of Electrical Engineering.

It is therefore recommended[5] that the roentgenogram should be so made that the densities within the shadow of the chest are within the range of 0.40 and 1.50.

The Conditions under which the Finished Roentgenogram is Observed. No complete analysis of the conditions under which roentgenograms are observed has been made. Measurements by workers interested in the characteristics of vision and problems of illumination suggest certain requirements for viewing devices. These may be stated briefly:

(1) The intensity of the light at the surface of a viewing device over which the roentgenogram is to be mounted should be between 200 and 500 foot-candles.*

(2) The general illumination throughout the room should be of the order of magnitude of 5 foot-candles.

(3) Sources of glare should be carefully eliminated. For example, no viewing boxes should be illuminated except those actually being used.

These problems, and others associated with them, require further study. For example, the optimum color of the viewing box light is being investigated at the present time.[14]

The Classification of the Patient as a Roentgenographic Subject. A great variety of methods for classifying a patient for roentgenography is used.[11] None of these methods reduces the classification to a physical measurement. Until some physical means is devised for measuring the roentgen-ray absorption characteristics of the chest, the classification of the patient must depend, at least in part, upon personal judgment. So far as it is known, no comprehensive comparison of the methods now in use has been made.

For those patients who are thought to be within the range of what is called normal, the following procedure is reasonably accurate, although the accuracy depends upon the judgment of the technician:†

(1) The diameter of the chest of the patient, standing in normal posture, is measured in centimeters by means of calipers held in the horizontal plane of the axillae and the vertical plane of maximum diameter.

(2) A qualitative estimate of the physiological characteristics of the patient's chest is made and designated as follows:

A. Extremely thin chest walls.
B. Normal or average chest walls.
C. Greater than normal muscular or fat deposit over ribs.
D. Extremely fat, muscular patient.

Methods like the one above described are of practical importance at the present time, but it is necessary to solve the problem of measuring physically the roentgen-ray absorption characteristics of the patient's chest in order to predetermine the technique required for making the roentgenogram. An investigation is being made in the Moore School X-Ray Laboratory of a practical, scientific method of determination of the roentgen-ray absorption characteristics of the chest. It depends primarily upon the comparison between the ionization effects of two identical beams of roentgen rays, one of which impinges directly upon the ionization chamber, the other of which is intercepted by the chest to be measured before traversing the ionization chamber. This method has the inherent advantage of comparing the relative absorptive powers of chests to be roentgenographed, under conditions essentially the same as those prevailing during roentgenographic exposure. The perfection of the method would help to put the entire roentgenographic procedure upon an accurately standardized, scientific basis.

The Description of the High Voltage Generating Equipment. Many types of high voltage generating equipment are now installed in roentgen laboratories throughout the country. This apparatus represents the expenditure of a very large sum of money.

* An approximate idea of the order of magnitude of the foot-candle may be obtained from the following example. If a 60-watt inside frosted lamp is suspended without reflector, the light intensity 3 feet below the bulb is approximately 10 foot-candles.

† This method has proved satisfactory at the Laboratory of the Henry Phipps Institute, Philadelphia, under the supervision of Dr. F. Maurice McPhedran.

If it is possible to use such equipment to obtain good diagnostic roentgenograms, it is important to choose technical methods adapted to particular types of apparatus. Efforts should be made to devise these methods in such a manner that roentgenograms made with various types of equipment may be as nearly comparable as possible. It is proposed, therefore, to list below the inherent limitations of certain types of apparatus and so to specify several types satisfactory for chest roentgenography.

Apparatus with a capacity of less than 100 kv. (peak), 100 ma., should not be used for chest roentgenography. One of the necessary requirements for chest roentgenographic technique as described below is that the exposure time be as short as possible. In order to use short exposures a tube current of 100 ma. or more is necessary at the focal spot-film distances normally recommended.

Apparatus using half-wave rectification is not recommended for chest roentgenography. Certain unpredictable transient phenomena in such apparatus make it impossible to calibrate the equipment in a satisfactory manner. Furthermore, the life of roentgen tubes used with half-wave roentgenographic apparatus is less than that obtained with other types of equipment.[12]

Condenser discharge apparatus having a fixed capacitance of 1 microfarad is not satisfactory for roentgenography of thin adult chests. If this type of apparatus is to be used for chest roentgenography throughout the range of thicknesses normally encountered, the apparatus should be designed so that several values of capacitance from $\frac{1}{4}$ to 1 microfarad are available. When it is possible to vary the capacitance, the effective exposure time and the contrast in the roentgenogram may be made comparable for all normal chests.[6]

Single phase apparatus capable of delivering a tube current of more than 500 ma. and three phase apparatus will produce satisfactory chest roentgenograms, although the high cost of such apparatus and the difficulty of obtaining precise calibration make their use of doubtful value.

There remain the types of apparatus listed below which are recommended for chest roentgenography (*in the order of the current carrying capacity*):

(1) 100 kv. (peak), 100 ma., mechanically rectified.
(2) 100 kv. (peak), 300 ma., mechanically rectified.
(3) 100 kv. (peak), 300 ma., four-valve rectified.
(4) 100 kv. (peak), 500 ma., mechanically rectified.
(5) 100 kv. (peak), 500 ma., four-valve rectified.

These machines are listed in accordance with general, but not universal, methods of rating roentgen apparatus. For example, a machine which is rated by the manufacturer at 90 kv. (peak), 600 ma., may be included in (5) above.

It is to be emphasized that the present state of knowledge of roentgenography makes it possible only to recommend a group of different types of apparatus apparently equally satisfactory. The real problem of obtaining good roentgenograms of the chest lies more in the choice of methods for using the apparatus than in the choice of the apparatus itself.

The Characteristics of Roentgen Films and Intensifying Screens. Manufacturers of roentgen films attempt to produce material having the characteristics of high contrast, high speed and low processing fog. At the present stage of this development there are several important features to be considered.

The characteristics of film are such that poor contrast is obtained throughout those areas of the film upon which radiation of low intensity is incident. It is necessary therefore to choose a roentgenographic technique which produces densities of diagnostic interest greater than the values for which the contrast is low. Analysis of this problem results in the choice of 0.40 as the

minimum density within the diagnostic area as described above.

It is particularly important that the roentgen film used in a given laboratory should be maintained constant throughout the year. Tests for measuring the constancy of the film received in the laboratory have been described.[3] It should be emphasized that if it is desirable to obtain comparable roentgenograms it is more important to obtain film which is constant in roentgenographic quality than to change the type of film as small changes in quality are produced by the manufacturers.

The intensifying screens recommended by most manufacturers for chest roentgenography are made of crystals of calcium tungstate. The production of screens with equal speeds is difficult and it is therefore important to try to obtain a set of screens for chest work as nearly comparable as possible. These screens should be chosen for excellence of reproduction of detail, rather than for high intensifying speed. Methods for performing physical tests of intensifying screens have been described.[7]

The Materials and Technique Used for Processing the Roentgenograms. The time-temperature method for developing roentgen film should be followed carefully. It is particularly important to control the dark room procedure with care in order not to compromise the accuracy with which the remainder of the procedure is carried out.

Prepared chemicals for roentgen film developers should remain constant in quality. Recently, however, there has been evidence that changes in the constitution of these chemicals have been made by manufacturers without informing the roentgenologist. This leads to confusion, since an unpredictable error is introduced into the roentgenographic procedure. It would be extremely useful if manufacturers would maintain the formula of developing chemicals accurately and inform the roentgenologist of the introduction of new formulas.

The Focal Spot-Film Distance. There has been considerable agitation toward the use of focal spot-film distances of 6 feet or more. With due consideration of the limitations of roentgen equipment the use of focal spot-film distances greater than 6 feet cannot be justified. There is no demonstrated improvement in diagnostic quality resulting from the use of such long focal spot-film distances.

At a focal spot-film distance less than about 4 feet there is likely to be nonuniformity of radiation over the surface of the film and a gross enlargement of shadows which may be confusing.[8]

It is therefore recommended that focal spot-film distance in chest roentgenography be limited to the range between 4 and 6 feet, and that the particular distance chosen for a given laboratory should depend upon the type of roentgen apparatus used in the laboratory. Equipment with relatively low capacity should be used with a focal spot-film distance of 4 feet, while the higher powered apparatus may be used with focal spot-film distances up to 6 feet.[13]

The Roentgen Tube Voltage. The choice of roentgen tube voltages for chest roentgenography has not been completely investigated by scientific means. This choice depends upon many of the factors described above in a complicated manner. Furthermore, it has been conventional to measure the roentgen tube voltage by its peak value since this measurement is relatively simple. The electrical characteristics of different apparatus make the wave forms of the voltage considerably different. Therefore, the specification of the peak value is little more than a qualitative individual designation of quality and not a precise physical designation. Further study of this problem must be made before definite quantitative suggestions may be made.

Tentatively it may be stated that if the other technical factors are chosen in accord with the recommendations given in this paper, the roentgen tube peak voltages required for chest roentgenography will

vary from 50 to 80 kv. (peak), depending upon chest diameter.

The Exposure Time. Since the parts within the chest are in motion during roentgenographic exposure it is desirable to minimize the exposure time in order to avoid unsharpness due to this motion. It is, however, quite possible to carry this minimization too far. For a given roentgenographic problem reducing the exposure time requires an increase in tube current and this in turn makes necessary the use of a roentgen tube with a larger focal spot. The use of this larger focal spot produces greater geometric unsharpness.[9] Therefore, it is necessary to choose an exposure time which recognizes the necessary compromises between unsharpness due to motion and unsharpness due to focal spot size. The limits between which this compromise is satisfactory for the chest are 1/10 second and 1/30 second.[2]

The Roentgen Tube Current. The choice of the proper roentgen tube current depends upon all of the factors considered above. After these factors are chosen, that tube current is used which will produce required roentgenographic densities. It is clear that the tube current is limited by the electrical capacity of the high voltage generating apparatus. If, for example, this limiting capacity is 100 ma., it is necessary to use the maximum exposure time of 1/10 second and the minimum focal spot-film distance of 4 feet, in order to use tube voltages of the value necessary to obtain proper contrast.

Type of Roentgen Tube and the Focal Spot Size. Line or band focus roentgen tubes are recommended for chest roentgenography, since the small effective focal spot obtained by the use of such tubes is an important factor in the reduction of geometric unsharpness. In most of the line focus tubes now available, the angle between the plane of the focal spot and the central roentgen beam is about 20°, although a few are made having an angle of 10°. Throughout the area of the roentgenogram the geometric unsharpness will vary, since the projection of the focal spot has different sizes and shapes in different directions. This matter has received detailed consideration.[1] Roentgen tubes with an angle of 20° should not be used at focal spot-film distances less than 4 feet; roentgen tubes with an angle of 10° should not be used at focal spot-film distances less than 6 feet. At smaller distances it is probable that films will appear lighter on the side of the anode and darker on the side of the cathode, due to absorption of roentgen rays and non-uniformity of radiation.

The size of the focal spot should be chosen so that within the limits of tube voltage, tube current and exposure time which have been selected, the power dissipated at the focal spot should not exceed 250 watts per square millimeter.[10]

If the anode of the roentgen tube is rotated during exposure, and the tube is so constructed that different areas of tungsten are sources of roentgen rays at different instants of exposure, the focal spot may be made considerably smaller for a given exposure than that of a stationary anode tube. Such tubes have been constructed for some years. Considerable technical improvement is obtained by the use of these tubes, since a focal spot about 2.5 mm. sq. can be used for a rotating anode tube for exposures which would require a stationary anode tube with a focal spot 5 or 6 mm. sq.

SUMMARY

Upon the basis of recent studies of the physical characteristics of roentgen apparatus, the following ranges of technical factors are recommended for chest roentgenography:

High voltage generating equipment with a capacity of 100 kv. (peak), 100 ma., to 100 kv. (peak), 500 ma., using full wave rectification.

A synchronous impulse timer which makes and breaks the primary circuit at instants of zero current and a cathode current stabilizer connected in the low tension cathode circuit should be used.

Roentgen films which are constant, and carefully chosen intensifying screens giving a maximum of detail.

Standardized developing procedure, based upon standardized materials.

Focal spot-film distances between 4 and 6 feet.

Roentgen tube voltages between the limits of 50 and 80 kv. (peak).

Exposure times between 1/30 and 1/10 second, depending upon the capacity of the apparatus.

Roentgen tube currents between 100 and 500 ma.

Roentgen tube of the line focus type, with a focal spot size chosen upon the basis of the roentgen tube voltage and tube current used.

With any particular apparatus the exact values of the factors mentioned above should be so chosen that the maximum and minimum densities within the diagnostic areas of the chest roentgenograms are respectively 1.5 and 0.4.

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EPIPHYSIS FOR THE LESSER TROCHANTER

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IN THE course of investigations into the age of appearance and fusion of epiphyses in different parts of the body, the following figures have reference to that of the lesser trochanter:

Ages	Instances in females	Instances in males	Centers in females	Centers in males
8	8	8	0	0
9	10	12	6	1
10	0	13	0	3
11	9	10	3	0
12	7	11	0	6
13	4	4	0	0
14	6	13	0	11
15	4	13	0	10
16	7	10	1	4
17	5	16	0	4
18 to 23	68	63	0	0
24	14	9	1	0

In the above series the youngest girl with such epiphysis was aged nine years, the youngest boy nine years and one month; Morrison illustrates its presence in a subject aged eight, but he omits to mention which sex. The maximum incidence appears to be in girls at the age of nine and boys at the age of fourteen. Although this center was present 39 times in 99 instances of boys aged nine to seventeen it was noted only 7 times in 49 girls of the same age. It seems very probable that this center is not constant and perhaps is much more common in boys than in girls. Centers were likewise seen in a girl aged sixteen years and ten months and in a boy aged seventeen years and eleven months. Although not once seen in 130 instances between the ages of eighteen and twenty-three, it was seen in a woman aged twenty-four.

Other inconstant epiphyses are those for the tuber ischii and to a lesser extent the medial extremity of the clavicle.

Burman, no doubt guided by current anatomical textbooks, gives the age of appearance of the epiphysis for the lesser trochanter as eight to ten with fusion at eighteen. These however give an extremely rough idea of true facts. Moreover he illustrates a view of a girl aged fourteen, which is diagnosed "epiphysitis," yet neither from the description nor from the views does an epiphysis appear to be present.

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EPIPHYSIS FOR SYMPHYSIS PUBIS

DOES SUCH EXIST?

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AN EPIPHYSIS for the symphysis pubis is so constantly described in practically every textbook of anatomy that its existence is taken for granted by all, including roentgenologists. Even in the excellent article on "The Symphysis Pubis in the Female" by Barnes in the issue of the AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY for September, 1934, it is stated on page 334, "An isolated secondary ossification center is *often* found in the cartilage in the superior outer part of the joint."

Nevertheless in 1932, I reported in the *Journal of Anatomy* for October that after examination of a large series of symphyses of patients of both sexes and at all ages, but more particularly between fourteen and twenty-two, not in a single instance could it be found by roentgenological methods despite the ease with which this joint can be clearly demonstrated. The minimum number of pelves scrutinized were as follows:

Age 14 10	Age 17 18	Age 20 25
Age 15 16	Age 18 28	Age 21 26
Age 16 18	Age 19 20	Age 22 29

A careful search through the literature has failed to reveal a single instance where such an epiphysis has been demonstrated roentgenologically. One must therefore come to the conclusion either that it does not exist or that it is very rare. The same remarks apply to the alleged epiphyses about the pubic crest or pubic spine.

Has any roentgenologist ever satisfactorily demonstrated the existence of these centers? If so, they should be put on record, and if not, the various textbooks should cease to record them.

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Committee on Arrangements: E. H. Skinner, Chairman, Kansas City, Mo., E. K. Robinson, Kansas City, Mo., W. R. Brooksher, Fort Smith, Ark.

Twenty-first Annual Meeting: Kansas City, Mo., May 11-12, 1936.

EDITORIAL

THE NEUTRON

WITHIN the last four years a development has been going on which in many ways parallels the discovery and development of the roentgen ray, and which we now have every reason to believe will equal that historic discovery in importance. Already the production of beams capable of penetrating considerable thicknesses of dense material, the transmutation of chemical elements upward in the periodic table, and the production of artificially radioactive elements both in numbers and in quantities never dreamed of heretofore, are accomplished facts. These developments have brought with them a revolution in the field of theoretical physics, and an entirely new chemistry.

These facts make a firm basis on which can be built working hypotheses for the development which is now going on all over the world at a tremendous pace.

Like the roentgen ray, the neutron was first observed in the form of a new penetrating radiation, and in such weak intensity that great credit is due to Bothe and Becker[1] that they observed it at all. Similar weak intensities of the same nature had been observed earlier[2] but had failed of repetition and been passed over. These physicists, using a weak source (6–7 millicuries) of polonium, bombarded a number of elements with alpha particles and produced a "penetrating radiation." They observed that the absorption of this radiation in heavy elements was slight, and that the amount produced was far greater when the element bombarded was beryllium than with any of the other elements they tried.

The work was taken up at once by the Curie-Joliots who had a source of "centain millicurie de Polonium," and were able to produce the new radiation in far greater quantity than Bothe and Becker. In 1931 they[3] published a paper in which they described the production and measurement of this new radiation in detail. At that time they believed the new radiation to be gamma rays, and so described it. However, they had made careful measurements of the coefficient of absorption of this radiation in lead and had found it to be of the order of 0.15, while the μ/ρ value for ordinary gamma rays is about 2.6. From this they calculated that the energy of these new gamma rays, produced by atomic disintegration, was of the order of twenty million electron volts.

From this point on, these investigators worked so fast and so effectively, and published so many reports[4] that the details must be omitted. They brought out two more facts of fundamental importance, both of which were inconsistent with the well-established laws of absorption for gamma rays, first that the absorption of these new gamma rays did not increase consistently with the atomic number of the element in the absorbing filter; and second that when a screen of cellophane, paraffin, water or any material containing hydrogen was interposed between the source

[1] Bothe, W., and Becker, H., Künstliche Erregung von Kern Strahlen. *Ztschr. of Phys.*, 1930, *66*, 289–306.

[2] Slater, F. P. The excitation of gamma radiation by alpha particles from radium emanation. *Phil. Mag.*, 1921, *42*, 904–923.

[3] Curie, Irene. Nuclear gamma rays from beryllium and lithium excited by α rays from polonium. *Compt. rend.*, 1931, *193*, 1412–1414.

[4] Curie, Irene, and Joliot, F. The emission of high-speed protons by hydrogen compounds under the influence of gamma rays of high penetration. *Compt. rend.*, 1932, *194*, 273–275.

Curie, I., and Joliot, F. The effect of the absorption of x-rays on the projection of nuclear radiation. *Compt rend.*, 1932, *194*, 708–711.

Curie, I., and Joliot, F. The projection of atoms by very penetrating radiation excited in light nuclei. *Compt. rend.*, 1932, *194*, 876–877.

Curie, I., and Joliot, F. The nature of the penetrating radiation excited in light nuclei by α particles. *Compt. rend.*, 1932, *194*, 1229–1232.

Curie, I., Joliot F., and Savel, P. Radiations excited by α rays in light elements. *Compt. rend.*, 1932, *194*, 2208–2211.

and the ionization chamber, instead of being decreased, the ionization current was very greatly increased. This is itself was not so startling because the ability of gamma rays to throw secondary electrons out of a filter and give a high ionization current reading when the filter is close to the chamber is very well known. However, the Curie-Joliots applied a strong magnetic field in the path of the radiation, so strong that secondary electrons of any conceivable velocity would have been bent back and driven away from the ionization chamber. This field had no practical effect on the measurements.

These investigators had no explanation for these inconsistent facts, for they were still under the impression that they were dealing with the gamma rays; but fine scientists that they are, having proved that these were facts, they published them without explanation.

Here the history of the neutron differs in an important respect from the history of the roentgen ray. After Röntgen's discovery of his "new kind of light," nearly twenty years had to pass before it was conclusively demonstrated that his ray actually was a form of light, that is, an electromagnetic wave. In the case of the neutron, its true nature was demonstrated within a few months after its discovery.

Curie and Joliot, having demonstrated that the excess ionization observed from the screen of hydrogen-containing material did not come from secondary electrons, went on to demonstrate that it did come from fast protons thrown out from the hydrogen atoms. This they did in two ways, by interposing thin aluminum screens which would have allowed fast secondary electrons to pass through, but were sufficiently thick to stop hydrogen nuclei (in the same manner in which thin screens were used to stop alpha particles and permit the passage of beta rays), and by throwing these same secondary protons into a cloud chamber and studying their tracks.

At this point Chadwick,[5] at the Cavendish Laboratory, took up the study. Within one month he was able to report results of measurements of this new radiation with Geiger counters and cloud chambers. He quickly demonstrated that this new ray could impart high velocities to the nuclei of other light elements beside hydrogen. He was able to measure tracks from the nuclei of nitrogen, oxygen, carbon, etc., and from these tracks to measure the energy with which these nuclei were accelerated, and hence the energy that this new ray was able to deliver upon impact. From these measurements he proved that the supposed gamma ray which was throwing out these secondary protons was not a "ray" at all, that is, the primary energy was not a light photon but an actual material particle. This particle, he was able to prove, had about the same mass as a hydrogen nucleus, *and no electrical charge whatever*. This in itself was a revolutionary discovery, but Chadwick was able to demonstrate the truth of his findings, and named the new particle the "neutron."

This discovery brought up a beautiful group of theoretical problems. The first thing Chadwick had to try to answer was whether the neutron was a separate entity, hence one of the fundamental building blocks of the universe, or whether it was a proton with a closely bound electron which just neutralized the positive charge. To add to the confusion (which was more apparent than real) in the summer of 1932 Anderson[6] at the California Institute of Technology discovered the positive electron. This proof that the positive charge could exist free from the mass of the nucleus first threw possible doubt on the old and well-established belief that the proton, the nucleus of

[5] Chadwick, J. Possible existence of a neutron. *Nature*, 1932, *129*, 312.

Chadwick, J. Existence of a neutron. *Royal Society of London, Proceedings Series A 136*, 1932, 692–708.

Feather, N. Collisions of neutrons with nitrogen nuclei. *Royal Society of London, Proceedings Series A 136*, 1932, 709–27.

Dee, P. I. Attempts to detect the interaction of neutrons with electrons. *Royal Society of London, Proceedings Series A 136*, 1932, 727–734.

Webster, H. C. The artificial production of γ radiation. *Royal Society of London, Proceedings Series A 136*, 1932, 428–453.

[6] Anderson, Carl D. Apparent existence of easily deflectable positives. *Science*, 1932, *76*, 238–239.

the hydrogen atom, was the positive fundamental entity. Lacking further proof it was possible to assume that the "proton" as a separate entity did not exist, but actually consisted of a neutron and a positron. Fundamental considerations of mass and energy served to clear up these questions and establish the neutron as a newly discovered fundamental entity. Soon thereafter it was demonstrated conclusively that the proton and neutron can exist together in the nucleus. From the allied field of chemistry came the discovery of "heavy water"[7] of which the hydrogen was found to be the anomalous element, called "heavy hydrogen" and later for good reason named "deuterium." This is the simplest element containing in its nucleus both a proton and a neutron. The free ion from heavy hydrogen is called a "deuteron."

Naturally the discovery of the neutron brought up two general practical problems, the first, how to produce it, the second, how to use it. Neutrons were first produced by bombarding atomic nuclei with alpha rays, and are still produced in the same manner. Practically this is done by mixing metallic beryllium, which gives the best yield of neutrons, with radium or radon; or possibly other radioactive elements such as polonium where these are available. This method, however, gives a very feeble source of neutrons, suitable for a standard of comparison which may be used to check meters as radium is used to check instruments for the measurement of roentgen rays.

Since the supply of natural alpha particles is hopelessly limited, the first problem was to produce them artificially. This was done by Lauritsen[8] with his one million two hundred thousand volt tube. His work was immediately followed by others,[9] in fact by everyone who had a source of high voltage available. The methods followed by all these workers were in general the same. Atoms were ionized by some regular method and then accelerated in a straight line through a tube to which a very high voltage was applied. In this way the atomic nuclei were made to approach the speed of alpha particles, which are helium nuclei, and were then brought to a focus on the target to be bombarded. Lawrence[10] of the University of California obtained the same results by a different method, and was able to reach even higher speeds without the use of very much voltage. His apparatus, called the cyclotron, consists of a very heavy magnet with the ion accelerating device between its pole pieces. This device consists of a vacuum tight metal box containing two flat hemicylindrical electrodes. These are connected to an oscillator which produces only about fifteen thousand volts, but at high frequency. All other accelerating devices are like roentgen tubes in that they work on direct current, or upon one half-cycle only of an alternating current. In the cyclotron deuterium gas passes into the evacuated box and is ionized at its center. Ions then start to move in the electrical field between the two electrodes. When they have both electrical charge and motion, they constitute an electric current, and the magnetic field causes them to take a curved path and rotate like the armature in an electric motor. On each rotation they pass twice through the field between the two electrodes, and with each pass they receive a new acceleration. In this way a very high speed is built up, but as the speed increases the curvature of their path in the magnetic field necessarily decreases, and consequently they follow a spiral path from center to circumference. When they finally reach the outside edge where the target is located, they have a speed equal to the acceleration due to several millions of volts.

Before any of these ponderous machines could be made to work, Cockroft and

[7] Urey, Harold C., Brickwedde, and Murphy, G. M. A hydrogen isotope of mass 2. *Phys. Rev.*, 1932, *39*, 164–165.

[8] Lauritsen, C. C., and Bennett, R. D. A new high potential x-ray tube. *Phys. Rev.*, 1928, *32*, 850–857.

[9] Tuve, M. A. Atomic nucleus and high voltages. *J. Franklin Inst.*, 1933, *216*, 1–38.

[10] Lewis, G. N., Livingston, S. M., and Lawrence, E. O., The emission of α particles from various targets bombarded by deutons of high speed. *Phys. Rev.*, 1933, *44*, 55–56.

Walton[11] at Cambridge, England, reasoning from theoretical wave mechanics, had come to the conclusion that some transformations should occur at low voltage, of the order of 100 kv. They demonstrated this to be true, and by so doing may have opened up the most valuable channel for present and future development.

This serves as a bare but fairly complete outline of the methods so far developed for the production of neutrons and artificial nuclear disruptions. The best methods are probably yet to be developed, but at this same time, more than forty years after the discovery of the roentgen ray, we are still developing methods of producing and controlling this valuable form of energy. It speaks well for the cooperation existing between all nations of the scientific world that so much has been done in less than four years.

At the present time it appears that the use of neutrons in medicine and in industry will be indirect, that is, they will be used for the production of radioactive substances which then will find a direct use. This is not necessarily true. It may very well be that with improvements in the methods of producing neutrons, we may obtain intense sources and find direct uses for them, uses of which as yet we have no idea.

Mention has already been made of the fact that the Curie-Joliots found discrepancies in the action of different metallic filters. In the case of the roentgen ray, every roentgenologist is familiar with the fact that in general the absorbing power of a filter increases with its atomic number. A thin lead filter absorbs more radiation than a copper filter of equal thickness. The only exceptions occur at wave lengths where an absorption edge is encountered for the filter under consideration. In the case of the neutron beam this is not true. Each chemical element has its own specific absorbing power for the new radiation. A convenient way has been found of expressing this absorbing power as the "collision cross section." In general, the term might be explained as follows: Since matter actually consists of very small particles of solid substance with relatively great spaces between them, we might make an analogy and liken a metal plate used as a filter to a very large mesh net, with balls hung in the corners of the meshes. If we now try to throw tennis balls through this net, a certain number will pass through, and a certain number will collide with the suspended balls. If these balls on the net are golf balls, tennis balls or basket balls, different fractions of the missiles thrown will pass through in each case. We might then express the "absorbing power" of the mythical net as a function of the size (i.e., the cross section) of the balls suspended in its corners; naturally the size of the ball thrown must be considered also.

These collision cross sections have been measured for practically every element in the periodic table, and a complete table has been published by Dunning and his coworkers.[12] Selecting a few elements from this table by way of illustration, we might take three common ones, silver, cadmium and tin, atomic numbers 47, 48, and 50. For slow neutrons these elements have cross sections of 55, 3300, and 4.0 respectively. It is obvious then that if we wished to protect ourselves from neutrons we would choose cadmium of the three elements listed; in fact, as a protective agent cadmium is only exceeded in efficiency by gadolinium, a very rare metal. On the same basis of comparison, lead has a cross section of 8.6. It may be noted in passing that element No. 49 is omitted from the above consideration. This element is indium, a good absorber used as an indicator for measuring the intensity of neutron beams, but again a rare metal with a present market price of three dollars a gram, and hence hardly need be considered as protective material.

[11] Cockroft, J. D., and Walton, E. T. S. Experiments with high velocity positive ions. *II.* Distintegration of elements by high velocity protons. *Royal Society of London, Proc. Series A 137*, 1932, 229–242.

[12] Dunning, J. R., Pegram, G. B., Fink, G. A., and Mitchell, D. P. Interaction of neutrons with matter. *Phys. Rev.*, 1935, *48*, 265–280.

When an atom absorbs a neutron several things may happen. Probably the first such reaction was observed by Feather[5] who measured the tracks produced when a neutron struck a nitrogen atom, and deduced the reaction:

$$N^{14}+n^{1}=B^{11}+He^{4}$$

This is a transmutation reaction in which an atom of nitrogen when struck by a neutron is transformed into an atom of boron and an alpha particle. The reaction is reversible, for when boron is bombarded with alpha particles, as in the first experiments mentioned, neutrons are produced.

One of the first reactions produced by Lawrence[13] with his cyclotron was the radioactivation of sodium. In this case the same reaction will work (as in most cases) when either neutrons as such or deuterons are used as the bombarding agent:

$$Na^{23}+n^{1}=Na^{24}$$

or

$$Na^{23}+D^{2}=Na^{24}+H^{1}$$

This isotope of radium is radioactive and breaks down giving both beta and gamma rays:

$$_{11}Na^{24}=_{12}Mg^{24}+\beta+\gamma$$

In this case a transmutation has taken place upward in the periodic system with the production of a new radioactive substance which disintegrates with a half life of 15.5 hours to give beta and gamma radiation and an inert non-poisonous end product. If magnesium had been used our equation might have shown the production of radiomagnesium which gives both beta and gamma rays and ends up as an isotope of aluminium,[14] half life ten minutes.

If this were a review of the subject of artificial radioactivity, we would have to go on and detail several other types of reaction. For our purpose, it is enough to say that these reactions have been tried on nearly every element of the periodic table. From these radioactivated substances formed by bombarding ordinary substances with neutrons, we can obtain nearly any sort of a radioactive product desired, with half lives from a few seconds (fluorine, ten seconds) to much longer periods of time. By judicious choice of the element to be activated we can get gamma or beta rays or positrons as our radiant energy, have an element of short half life produced, and finish with a non-toxic end product.

We have mentioned "slow neutrons" and the production of positrons without explanation. (1) It has been shown by Fermi[15] and others that better absorption of neutrons by the substance to be activated is obtained if the neutrons are first slowed down by passing them through water or paraffin. Usually the substance to be activated is dissolved or immersed in this medium so that not only the "incident," but also the "backscattering beam" is utilized. (2) Where positrons are produced from one of these disintegrations they only exist as such while they retain their high velocity. After passing through enough matter to be slowed down they combine with a negative electron with resulting total destruction of their mass and the production of two quanta of 500 kv. radiation.

On the basis of these facts we are justified in making enough predictions to serve as a basis for the work of the immediate future. Work of a physiological nature has already been begun both with artificially radioactivated elements and with neutrons. As yet none of this work is completed and published, although some of it may be within a short time. For example, we may predict that the use of radiocalcium and phosphorus may help in studying the metabolism of these elements. It is possible that these elements may be made to con-

[13] Lawrence, E. O., Transmutations of sodium by deutrons. *Phys. Rev.*, 1935, *47*, 17–27.

[14] Henderson, M. C. Two radioactive substances from magnesium after deuteron bombardment. *Phys. Rev.*, 1935, *48*, 855–861.

[15] Fermi, E., Amaldi, E., D'Agostino, O., Rasetti, F., and Segie, E. I. Artificial radioactivity produced by neutron bombardment. *Royal Society of London, Proc. Series A 146*, 1934, 483–500.

Amaldi, E., D'Agostino, O., Fermi, E., Pontecorvo, B., Rasetti, F., and Segie, E. II. Artificial radioactivity produced by neutron bombardment. *Royal Society of London, Proc. Series A 149*, 522–558.

centrate in bone lesions and bring to light incipient pathology. It is even possible that they may be made to concentrate in bone neoplasms in such force that the neoplasm will be destroyed. It remains to be seen whether they will assist or inhibit the healing of an injury. Radio-iodine may have a desirable (or a very detrimental) effect in thyroid disorders, and if substituted in phenoltetraiodophthalein we may have a "radio-iodicon," useful in disorders of the liver and gallbladder. Anyone trained in roentgen diagnosis and therapy can extend this speculative list indefinitely. Undoubtedly many of our guesses will not be practical; undoubtedly some of them will, when more is known about the subject.

One of the most promising fields of speculation at the present time is the possibility of producing these radio-elements and bringing them under control for direct injection into neoplasms. Forty or more elements are known to have beta-ray activity, and at least two, positron activity. It is possible that some of these elements, properly chosen, could be injected directly into a malignant growth in sufficient quantity to destroy it, and yet due to their short half life be carried away through the blood stream as innocuous substances.

Three facts stand out: first, that these radioactive elements can be produced and measured; second, that they have short lives, and third, that many of them form non-poisonous end products. On this future work must be based.

K. E. Corrigan

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. E. P. Pendergrass, University Hospital, Philadelphia, Pa. Annual Meeting: Cleveland, Ohio, Sept. 29–Oct. 2, 1936.

American College of Radiology
Secretary, Dr. B. H. Orndoff, 2561 N. Clark Street, Chicago, Ill. Annual meeting: Kansas City, Mo., 1936.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: Kansas City, Mo., May 11–15, 1936.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N.Y. Annual meeting, 1936: To be announced.

Radiological Section, Baltimore City Medical Society
Secretary, Dr. W. B. Firor, 1100 N. Charles St., Baltimore. Meets third Tuesday each month, September to May.

Radiological Section, Connecticut State Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets annually in May. Special meetings may be called by the Chairman.

Radiological Section, Los Angeles County Medical Society
Secretary, E. N. Liljedahl, Los Angeles, Calif. Meets on the second Wednesday of each month at the County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas. Annual meeting, Baltimore, Md., Nov. 17–20, 1936.

Brooklyn Roentgen Ray Society
Secretary, Dr. E. Mendelson, 120 E. 19th St., Brooklyn, N. Y. Meets monthly on first Tuesday, October to April.

Buffalo Radiological Society
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months, place of meeting selected by the host.

Chicago Roentgen Society
Secretary, Dr. R. G. Willy, 1138 N. Leavitt. Meets second Thursday of each month October to May inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. H. G. Reineke, General Hospital Cincinnati, Ohio. Meets third Monday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, North W. Shetter, M.D., 14600 Detroit Ave. Meetings are held at 6:30 P.M. at the Cleveland Chamber of Commerce Club rooms on the fourth Monday of each month from October to April, inclusive.

Denver Radiological Club
Secretary, Dr. K. D. A. Allen, 452 Metropolitan Building, Denver, Colorado. Meets on any month having a fifth Monday.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne Country Medical Society Building.

Florida State Radiological Society
Secretary, Dr. Gerard Raap, Miami, Florida. Meetings held twice a year, May and November.

Illinois Radiological Society
Secretary, Dr. Cesare Gianturco, 602 W. University Ave., Urbana, Ill. Regular meetings held quarterly.

Indiana Roentgen Society
Secretary, Dr. J. N. Collins, Indianapolis, Ind. Meeting held the second Sunday in May annually.

Long Island Radiological Society
Secretary, Dr. M. Dannenberg, 1464 Eastern Parkway, Brooklyn, N. Y. Meets on third Thursday of each month from October to May, at 8:30 P.M.

Michigan Association of Roentgenologists
Secretary, Dr. C. S. Davenport, St. Lawrence Hospital, Lansing, Mich. Three meetings a year, Fall, Winter, and Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. S. A. Morton, Columbia Hospital, Milwaukee, Wis. Meets monthly. Place of meeting designed by the president.

Minnesota Radiological Society
Secretary, Dr. L. G. Rigler, University Hospital, Minneapolis, Minn. Meets in St. Paul, Minn., in March, 1936.

Nebraska State Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday evening of each month.

New England Roentgen Ray Society
Secretary, Dr. Thomas R. Healy, 370 Marlboro St., Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. P. S. Avery, New Brunswick, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place designated by the president.

New York Roentgen Society
Secretary, Dr. E. F. Merrill, 30 W. 59th St., New York. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse, N. Y. Three meetings a year—January, May, and November.

Pacific Roentgen Club
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, Williamsport, Pa. Next annual meeting June 5 and 6, 1936, Lycoming Hotel, Williamsport, Pa.

Philadelphia Roentgen Ray Society
Secretary, Dr. Thomas Loughery, Germantown Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Camp C. Thomas, 476 Lake Ave. Meets on second Thursday from October to May, inclusive, 8 P.M., Rochester Academy of Medicine Building.

St. Louis Roentgen Ray Society
Secretary, Dr. P. C. Schnoebelen, Missouri Bldg., St. Louis, Mo. Meets first week of each month. Time and place of meetings designated by president.

South Carolina X-Ray Society
Secretary, Dr. R. B. Taft, 105 Rutledge Ave., Charleston Meets at time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary-Treasurer, Dr. J. H. Smith, Lubbock, Texas
Meets annually one day preceding the meeting of the Texas State Medical Association.

University of Michigan Department of Roentgenology Staff Meeting
Secretary, Dr C. B. Peirce, University Hospital, Ann Arbor, Mich.
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Roentgen Club
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis.
Meets monthly on last Thursday, October to April, Service Memorial Institute, at 4:30 P.M.

Virginia Roentgen Ray Club
Secretary, Dr. V. W. Archer, University Hospital, University, Va.
Meets annually in October.

Cuba

Sociedad Cubana de Radiologia y Fisioterapia
Secretary, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets on the third Thursday of each month, from November to June inclusive, at 8:15 P.M., at 32 Welbeck St., London, W. 1, or as advertised.

Electro-Therapeutic Section of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:30 P.M. at the Royal Society of Medicine, 1 Wimpole St., London, W. 1.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Colin Macdonald, Lister House, 61 Collins St., Melbourne, Australia.
Meets monthly at Melbourne during the winter.

Section on Radiology, Canadian Medical Association
Secretary, Dr. A. H. Rolph, 160 St. George St., Toronto, Ont.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. P. C. Fenwick, The Hospital, Christchurch. Meets annually.

Continental Europe

Belgian Society of Roentgenology
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

Sociedad Española de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7, Madrid, Spain. Meets monthly in Madrid.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel.
Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
Secretary, Dr. Walter Altschul, German University, Prague, 11.52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Süd- und Westdeutsche Röntgengesellschaft
Meets annually in different cities.

Nord- und Ostdeutsche Röntgengesellschaft
Meets annually in different cities.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the Spring, and one in the Fall.

Societa Italiana Radiologia Medica
Secretary, Professor M. Ponzio, University of Turin, Turin.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. G. Gatoschi, Str. Isvor 14–16, Bucarest.
Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson.
Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

Polish Society of Radiology
Secretary, Dr. Jan. Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime.

Society of Medical Radiology in Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
Secretary, Dr. G. Biering, Copenhagen.
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Roentgen Society
Meets first Wednesday of each month, at 6.30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University.
Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto Japan. Meets bi-monthly on third Sunday.

AMERICAN RADIUM SOCIETY

The Twentieth Annual Meeting of the American Radium Society will be held at the Hotel Kansas Citian, Kansas City, Missouri, on Monday and Tuesday, May 11 and 12, 1936. Dr. George W. Grier of Pittsburgh is President and Dr. Edward H. Skinner of Kansas City is Secretary. Dr. Zoe Allison Johnston of Pittsburgh is President-Elect and will be installed as President at the opening session.

A feature of the meeting is the Janeway Lecture which serves to honor a pioneer radium therapist, the late Dr. Henry H. Janeway. The Lecture will be given by Dr. Curtis F. Burnam of Baltimore, at the Annual Banquet on Monday evening at the University Club. Dr. Douglas Quick is Chairman of the Janeway Lecture Committee and will present the Janeway medals to Dr. Burnam, and the previous lecturers who were Dr. James Ewing and Dr. Francis Carter Wood of New York, and Dr. George E. Pfahler of Philadelphia.

The program of the meeting follows.

Monday, May 11, 1936

MORNING SESSION

Address of the President—George W. Grier, M.D., Pittsburgh, Pa.

Measurement of Radium Rays in terms of the Roentgen. G. Failla, Ph.D., New York.

Experimental Work for the Measurement of Radium Rays in Terms of the Roentgen. Edith H. Quimby, M.S., New York.

Present State of Physical Radium Dosimetry. Otto Glasser, Ph.D., Cleveland, Ohio.

Protracted Irradiation by Radium. Hayes E. Martin, M.D., New York.

Monday, May 11, 1936

AFTERNOON SESSION

Limitation of Radium Therapy in Cancer of the Cervix. Palmer Findley, M.D., Omaha, Nebr.

Histologic Changes and Clinical Results in the Radiation Treatment of Corpus Cancer. A. N. Arneson, M.D., New York.

The Calculation of the Dosage in Treatment of the Cervix. Charles DeF. Lucas, M.D., New York.

Treatment of Complications Occurring in Cases of Carcinoma of the Cervix Uteri. H. H. Bowing, M.D., Rochester, Minn.

Cancer of the Cervix as Treated at the Brooklyn Cancer Institute. (Moving Pictures.) Hyman Strauss, M.D., Brooklyn, N. Y.

ANNUAL BANQUET

Monday evening, May 11, 1936, University Club.

Janeway Lecture. By Curtis F. Burnam, M.D., Baltimore, Md.

Tuesday, May 12, 1936

MORNING SESSION

Cancer of the Breast Recurrent after Operation. Stanford Withers, M.D., Denver, Colo.

Cancer of the Breast. Frank E. Adair, M.D., New York.

Microscopic Grading; Its Interpretation, Limitations and Relation to Radiosensitivity. William C. MacCarty, M.D., Rochester, Minn.

The Relative Importance of Histological Analysis in Tumor Therapy. F. C. Helwig, M.D., Kansas City, Mo.

Tissue Changes Resultant from Radiation. Louis H. Jorstad, M.D., St. Louis, Mo.

Advanced Cancer of the Head and Neck. Charles L. Martin, M.D., Dallas, Texas.

Tuesday, May 12, 1936

AFTERNOON SESSION

Educational Advantages of the Tumor Clinic. G. M. Dorrance, M.D., Philadelphia.

Treatment of Menorrhagia and Uterine Fibroids. Curtis F. Burnam, M.D., Baltimore.

Advantages and Disadvantages of the Use of Radium Pack both Alone and in Association with X-ray and Surgery. William Howes, M.D. Brooklyn.

The Use of Radium Element Seeds in the Treatment of Cancer. George T. Pack, M.D., New York.

Protective Factors in the Preparation and Handling of Gold Implants and other Radon Applicators. Wilhelm Stenstrom, Ph.D., Minneapolis, Minn.

Radium Emanation. Ira I. Kaplan. M.D., New York.

MINNESOTA RADIOLOGICAL SOCIETY

The Spring Meeting of the Minnesota Radiological Society was held at the St. Paul Athletic Club, St. Paul, Minnesota, Saturday, March 28, 1936. The following program was presented:

1. Demonstration of Device for Serial Examination of the Duodenal Bulb. H. Milton Berg, M.D., Bismarck, N. D.
2. Roentgen Findings in Monilia Infection of the Lungs. Kano Ikeda, M.D., St. Paul, Minn.

3. Radium Treatment of Postoperative Parotitis. Robert Fricke, M.D., Rochester, Minn.
4. Roentgenologic Findings in Chronic Gastritis. Russell W. Morse, M.D., Minneapolis.
5. Roentgenologic Changes in Non-Tropical Sprue. John D. Camp. M.D., Rochester, Minn.
6. Congenital Solitary Kidney With Traumatic Rupture Clinically Diagnosed. Lester G. Ericksen, M.D., Dubuque, Iowa.
7. Roentgen Treatment of Carcinoma of the Ovaries. Lewis Jacobs, M.D., Minneapolis.
8. Roentgen Diagnostic Quiz. Conducted by Leo G. Rigler, M.D., Minneapolis.

An informal dinner was held, following which there was an address by the guest of the Society, Dr. Ernst A. Pohle of Madison, Wisconsin, on the "Radiological Treatment of Leukemia and Allied Disorders."

The next meeting of the Society will be held in connection with the meeting of the Minnesota State Medical Association in Rochester, Minn., May 4, 1936. Dr. Willis F. Manges of Philadelphia will be the guest speaker of the Society and will deliver the Carman Lecture before the members of the Minnesota State Medical Association on the subject "Foreign Bodies."

Leo G. Rigler, *Secretary*

INTERNATIONAL CONGRESS OF THE SCIENTIFIC AND SOCIAL CAMPAIGN AGAINST CANCER

The Second International Congress of the Scientific and Social Campaign against Cancer will be held in Brussels, Belgium, from September 20 to 26, 1936.

The Congress is being held under the High Patronage of His Majesty the King of the Belgians and of Her Majesty Queen Elisabeth. The program, which has been published by the National Organization Committee, takes up questions dealing with scientific cancerology and the social fight against cancer. The principal problems of scientific cancerology are: Biology (carcinogenic agents, factors of predisposition and of resistance against cancer: heredity, metabolism, immunity); Progress in the Establishment of the Diagnosis (histological, radiological, serological and serocytological diagnosis); Progress in Therapeutics (surgical and medical treatments, roentgen and radium therapy). The principal questions of the social campaign are: Access of Patients to Diagnosis and Treatment, Medico-social Assistance to Incurables, Cancer and Demography (statistics, cancer and races). The most highly renowned scientists of all countries, among whom are Dr. Dublin, Dr. Ewing, Dr. Lynch and Dr. Wood of the United States, have consented to give general reports.

For all detailed particulars, address the General Secretariat of the Congress, 13, rue de la Presse, Brussels, Belgium.

INTERNATIONAL CONGRESS FOR LIGHT

The Third International Congress for Light will be held in Wiesbaden, Germany, from September 1 to 7, 1936, under the presidency of Professor Dr. W. Friedrich, Director of the Institut für Strahlenforschung of the University of Berlin. At this Congress problems will be dealt with relating to the whole field of the biology of light, of biophysics, and the therapy of light. The titles of papers and any questions concerning the Congress should be addressed to the Secretary General, Dozent Dr. H. Schreiber, Robert Koch Platz 1, Berlin, N.W. 7, Germany.

RADIOLOGICAL SECTION, CONNECTICUT STATE MEDICAL SOCIETY

A meeting of the Radiological Section of the Connecticut State Medical Society was held at the Hartford Hospital, Thursday evening, April 9, 1936, at eight o'clock. Dr. Douglas Roberts and Dr. Ralph Ogden presented a paper on "Roentgen Diagnosis of Regional Ileitis." This was illustrated. Other interesting cases were shown and discussed by members of the Section. Dr. Charles W. Perkins of Norwalk is Chairman of the Section and Dr. Max Climan of Hartford is Secretary-Treasurer.

HOMAGE TO DOCTEUR ANTOINE BÉCLÈRE

The friends and pupils of Dr. Antoine Béclère have decided to celebrate the eightieth anniversary of his birth, March 17, 1936. On this occasion they will present him with a medal stamped with his image and a jubilee book containing a résumé of all his scientific work. The Journal wishes to add its expression of respect and admiration for the great life and work of Dr. Béclère, and its readers will be interested in securing either the medal or both the medal and the jubilee book. A slip to be filled out and mailed will be found elsewhere in the Journal.

BOOK REVIEWS

Books Received Are Acknowledged under Heading: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers as space permits.

Skin Cancer: A Clinical Study with Special Reference to Radium Treatment. By A. H. Wolfgang Magnusson. (*Acta radiol.*, Suppl. xxii.) Paper. Price, Swed. cr., 20: Pp. 287, with 10 plates. Stockholm: P. A. Norstedt & Söner, 1935.

This monograph deals in extenso with the various aspects of skin cancer and especially with the therapeutic results as obtained at the Radiumhemmet, Stockholm. The series includes 1,611 cases, all of which are arranged in an elaborate tabular form taking up the various phases such as age, previous history, condition on admission, type and extent of treatment, and the follow-up results. Neither cancers of the mucous orifices (lip, penis, vulva, anus) nor malignant nevic tumors nor precancerous dermatoses have been included. The histological classification was made according to Darier into squamous cell, basal cell, metatypical, mixed and intermediary type. On the basis of size and relation to the subcutaneous tissues the lesions were classified as infiltrating and superficial. The method of treatment, the one which is of chief interest to radiologists, consisted chiefly in application of radium. Roentgen rays were used only exceptionally and no special technique for this sort of treatment has been worked out.

As concerns the technique of the application of the radium, this was used either in the form of brachyradium or teleradium treatment. The first was carried out with radium containers (applicators) placed over the tumor surface at less than 3 cm. distance. Either plaques, needles or tubes were used, the amount of radium contained individually varying from 2.5 to 10 mg. radium element. The filtration was 0.15 mm. lead equivalent (calculated for hardest rays from radium B) for the flat containers, 0.9 mm. for the needles and 1.1 to 1.35 mm. for the tubes. The plaques were wrapped in stanniol paper during the application so as to prevent their getting soaked with secretion and to permit easier cleansing. The tubes with or without capsules for extra filtration have been set in protheses of dental compound, whereas the needles were applied chiefly interstitially. The second, that is, the teleradium treatment was applied at a distance greater than 3 cm. and usually over very extensive or bulky lesions. The dose in both instances was calculated so as to be as nearly as possible epidermicidal, that is, a dose which after about three weeks has been recognizable in the form of a superficial desquamation of the epithelium which has been healed after about six weeks. In the first years the doses were smaller and as a rule repeated within six to eight weeks for two or three series, but lately the practice is to administer all of the treatment in one single sitting. For tumors of less than 1 sq. cm. a 10 mg. radium element plaque with a surface of 1 sq. cm. is used for three hours (30 mg-hr.). In larger tumors, or sometimes even in the small tumors, extra filtration was provided to the plaques, flat containers or tubes and, if the distance between the outer wall of the applicator and the surface of the treated area was 2 to 4 mm. and the filtration equivalent to 1 mm. lead, the treatment time varied between three and eight hours according to the strength of the containers. The dose has then been 100 to 200 mg-hr. (about 50 mg-hr. per 1 sq. cm.). If the filtration was increased to 2 mm. lead equivalent and the distance to 4 to 8 mm. the time of treatment varied between ten and twenty hours, the dose thus being 400 to 1,000 mg-hr. (about 100 mg-hr. per 1 sq. cm.). In still larger superficial and infiltrating tumors a 3 mm. lead equivalent filter was used at a 6 to 10 mm. distance, this necessitating a treatment duration of twenty to forty hours, the dose being 1,000 to 2,000 mg-hr. (about 140 mg-hr. per 1 sq. cm.). The teleradium therapy was applied at 3 cm. distance with a dose of 10 to 20 mg-hr. and at 5 cm. distance with 25 to 40 mg-hr. (with suitable filter).

In tabulating the results a cure was assumed after an observation for at least three years. One thousand five hundred and two cases were treated exclusively by radiological methods and of these 69.3 ± 1.2 per cent were apparently cured. If one includes as cured all those who died of intercurrent disease but who were free of skin cancer at the time of death, the

three year cure percentage rises to 80.7±1 per cent. If the cases which were operated upon for recurrence or primarily operated upon (usually by endothermy) are included, the figures become 73.6±1.1 per cent and 86±0.7 per cent respectively.

In estimating the results from various angles such as histopathology, extent of invasion, clinical extension, etc., it was found that the size and extent of the tumor is the most important factor in estimating radiocurability. In superficial tumors the prognosis first becomes questionable when the tumor exceeds an area of 9 sq. cm. In infiltrating tumors the prognosis is poorer than for the superficial tumors of the same extent. The location of the tumor does not seem to have any influence except for the variation in the infiltrative capacity in different regions. As concerns the various techniques of radium application, it was found that in the surface application the results have been better with increasing filtration (minimum filtration equivalent to 1 mm. lead). The results with radium implantation whenever feasible were better than with surface application so that this method is considered technically simpler and more economical. As a whole, implantation is recommended for all cases of skin cancer where the exact extent of the tumor can be determined. Teleradium treatment is recommended for other cases.

In this series no case with clinically or histologically positive metastases from squamous cell cancer has been cured by any treatment. Metastases of tumors of the intermediary type seem sensitive to radium and a radiological cure of five years' duration has been obtained in one case where the metastases were histologically verified.

A very extensive bibliography and several plates showing the various histological appearance and some very unusual cases of radium cures are appended.

All in all, the volume gives a most comprehensive report for the type of treatment employed, displaying generously the thoroughness and efficacy of the system for which the Radiumhemmet has now become renowned.

T. Leucutia

Agents of Disease and Host Resistance, Including the Principles of Immunology, Bacteriology, Mycology, Protozoology, Parasitology, and Virus Diseases. By Frederick P. Gay. M.D., Director of the Department of Bacteriology, Columbia University, College of Physicians and Surgeons, New York; and (Nineteen) Associates. Cloth. Price, $10.00. Pp. 1582, with 212 illustrations. Springfield, Illinois: Charles C Thomas, 1935.

The encyclopedic scope of this volume is indicated by the title. As the preface states, a simpler alternative title might be: "The Etiology of Disease." The purpose of this comprehensive survey is "a new method of introduction and orientation in the science of disease."

There are 12 parts to the text. Part I deals with the general aspects of the causation, classification and nature of disease; Part II, with immediate disease agents and tolerance. Part III is devoted to living disease agents, particularly bacteria, their morphology and physiology. Infection and Epidemiology comprises Part IV; and Resistance and Immunity, Part V. Over 600 pages are next devoted to Part VI, Pathogenic Bacteria and Diseases Produced by Them. The next four parts deal with pathogenic spirochetes and spirochetoses; pathogenic fungi and fungus diseases; indeterminate pathogenic forms (viruses) and diseases produced by them; animal pathogens. The remaining two parts deal with disease of obscure etiology and with practical results in the diagnosis, prevention and cure of infectious diseases.

The book is compact with information, although one wonders if the publisher had this in mind when he described it in an advertising circular as a "compact volume," for it is a good sized tome. There are numerous illustrations, diagrams, charts and tables, many of them summarizing the facts in a striking manner. The historical and philosophical aspects of the subject matter are not ignored; and a wealth of references to the literature documents the text. In this connection, an author index would be of considerable use.

The printing is excellent and the book is capably designed. As seems to be the fate of many first editions, this has its share of misprints. Nevertheless, there seems to be no question that the book's intrinsic value will make it a useful reference text to all who are interested in infection and immunity.

Barnett Cohen

Untersuchungen über die Möglichkeiten einer dreidimensionalen röntgenographischen Abgrenzung innerer Organe des menschlichen Körpers. By Carl

Wegelius. Paper. Pp. 148, with 115 illustrations. Helsingfors: Mercators Tryckeri Aktiebolag, 1934.

The author has undertaken extensive studies in an attempt to outline roentgenographically inner organs, as, for instance, the heart, in three dimensions. After a thorough analysis of the underlying theory he describes the construction of a rather complicated looking apparatus which permits the roentgen examination of patients in three dimensions. Numerous illustrations show the results obtained by this method. The assumption is made that the organs are of convex contour, and anatomical as well as physiological facts seem to bear this out. How much more information can be gained by the author's method and if this gain will warrant the acquisition of the special apparatus needed for this procedure is difficult to say. The monograph is well illustrated; it also offers a short bibliography.

Ernst A. Pohle

La roentgenthérapie des fibromyomes de l'utérus et des métropathies hemorragiques. By Paul Gibert. Prèface du Docteur Antoine Béclère. Paper. Price, 18 fr. Pp. 111, with 10 illustrations. Paris: Masson et Cie., 1935.

This monograph reflects the author's experience during the last fourteen years in the treatment of uterine hemorrhages and uterine fibroids. It is chiefly addressed to the gynecologist and surgeon, who have not yet fully accepted the fact that excellent results may be obtained by proper radiation therapy in nonmalignant uterine disease. The author stresses a number of points which should form the basis of a better understanding between surgeon and radiologist. In the first place, a very careful examination, not omitting any one of the modern diagnostic means is imperative before arriving at the diagnosis of a benign uterine hemorrhage or uterine fibroid. Then follows an intelligent selection of suitable cases for irradiation; there are still certain types which require operation. Surgery and radiology are not competitive but cooperative fields of endeavor.

The opinion of the French school is briefly outlined, stating that the shrinking of the uterine fibroid is due to both a direct effect of roentgen rays on the growth and a secondary effect following cessation of ovarian function. Gibert prefers roentgen rays in the treatment of uterine hemorrhage and fibroid; he discusses his reasons and lists as some of the disadvantages of radium the necessary hospitalization, general anesthesia and danger of infection. The technique of irradiation, possible reactions following treatment and the probability of surgical intervention in cases of failure of radiation therapy are outlined. The author's statistics show a total of 350 patients belonging to this group treated during 1921–1933; 310 could be followed. Among these there were found five submucous fibroids, two cases of diagnostic errors, namely, one an ovarian cyst and one a carcinoma of the fundus of the uterus. Three patients were operated on while taking roentgen treatments and one patient required a second series of roentgen therapy.

While Gibert is quite enthusiastic regarding the efficacy of roentgen therapy in uterine hemorrhage and fibroids, he should be complimented for the first sentence of his conclusions: "Le fibromyome utérin est une affection extremement fréquente: reconnâitre son existence n'implique pas la nécessité d'un traitement actif."

Ernst A. Pohle

L'Action des rayons ultra-violets et des rayons X sur les nerfs périphériques. By Jacques Audiat, Docteur des Sciènces. Prèface du Professeur A. Strohl. Paper. Price, 25 fr. Pp. 88, with 23 illustrations. Paris: Masson et Cie., 1935.

This monograph presents the results of four years of experiments conducted by the author in the laboratory of A. Strohl. He studied the effect of ultraviolet and roentgen rays on the isolated ischiatic nerve of frogs. By means of special techniques developed by him, which are described in detail, the behavior of excitability, conductivity and action potential of nerves before and after exposure to the radiation was carefully recorded. It appeared that both ultraviolet and roentgen rays definitely affect the functional properties of the nerves. Up to a certain dose, the observed reactions were reversible. It was interesting to note that the leg of a frog showed temporary paralysis after irradiation of the exposed ischiatic nerve in situ. While the occurrence of a latent time between irradiation and effect seems to speak against a photochemical process as the basis of the observed phenomena, spectrophotometric studies of irradiated nerves make this explanation quite plausible.

Ernst A. Pohle

Diagnostic Roentgenology. Ross Golden, M.D., Editor, Professor of Radiology, the College of Physicians and Surgeons, Columbia University; Director of the Department of Radiology, Presbyterian Hospital, New York. Cloth. Loose leaf. Price, $20.00. Pp. 854, with 964 illustrations. New York: Thomas Nelson and Sons, 1936.

A Textbook of Roentgenology: The Roentgen Ray in Diagnosis and Treatment. By Bede J. Michael Harrison, M.B., Ch.M. D.M.R.E., (Cantab) F.A.C.R., Director of Department of Roentgenology, Vancouver General Hospital, Roentgenologist to Vancouver Public Health Institute for Diseases of the Chest. Cloth. Price, $10.00. Pp. 826, with 238 illustrations. Baltimore: William Wood & Co., 1936.

Dental Roentgenology. By LeRoy M. Ennis, D.D.S., Assistant Professor of Roentgenology in the Thomas W. Evans Museum and Dental Institute School of Dentistry, University of Pennsylvania; Instructor in Dental Roentgenology, in the Graduate School of Medicine, University of Pennsylvania, etc. Second edition, thoroughly revised. Cloth. Price, $6.50. Pp. 351, with 693 illustrations. Philadelphia: Lea & Febiger, 1936.

Étude anatomo-radiologique de l'appareil circulatoire par opacification post-mortem; intérêt, technique et valeur de cette méthode. By Docteur Pierre Hebert, Ancien Externe des Hôpitaux de Paris. Paper. Pp. 75, with 13 illustrations. Paris: Librairie E. Le François, 1935.

Anatomie radiologique des cavités cardiaques et du pédicule vasculaire. Par R. Heim de Balsac. Extrait des Leçons de Cardiologie Faites a l'Hopital Broussais.—1. Paper. Pp. 27, with 23 illustrations. Paris: Gaston Doin & Cie., 1936.

Das Ventrikulogramm. (*Acta radiol.*, Suppl. xxiv.) Von Erik Lysholm, Dozent für Medizin, Radiologie, Bertil Ebenius and Hans Sahlstedt. Assistenten am Röntgeninstitut. I. Teil. Röngentechnik. Paper. Price, Swed, cr. 10.–Pp. 75, with 74 illustrations. Stockholm: P. A. Norstedt & Söner, 1935.

Urethrography. (*Acta radiol.*, Suppl. xxviii.) By Folke Knutsson. Paper. Price, Swed. cr. 12.–Pp. 150, with 55 illustrations. Stockholm: P. A. Norstedt & Söner, 1935.

Clinical Tuberculosis. Edited by Benjamin Goldberg. M.D., F.A.C.P., F.A.P.H.A., Associate Professor of Medicine, University of Illinois College of Medicine, Honorary Professor of Medicine, National University of Mexico. Formerly Director of the City of Chicago Municipal Tuberculosis Sanitarium; with the collaboration of 33 contributors. Two volumes. Illustrated with over 640 halftone and line engravings and 9 full-page color plates. Cloth. Price, $22.00. Philadelphia: F. A. Davis Co., 1935.

Agents of Disease and Host Resistance, Including the Principles of Immunology, Bacteriology, Mycology, Protozoology, Parasitology, and Virus Diseases. By Frederick P. Gay, M.D., Director of the Department of Bacteriology, Columbia University, College of Physicians and Surgeons, New York; and (Nineteen) Associates. Cloth. Price, $10.00. Pp. 1582, with 212 illustrations. Springfield, Illinois: Charles C Thomas, 1935.

The Human Foot: Its Evolutionary Development, Physiology and Functional Disorders. By Dudley J. Morton, Associate Professor of Anatomy, College of Physicians and Surgeons, Columbia University, Cloth. Price, $3.00. Pp. 244, with 100 illustrations. New York: Columbia University Press, 1935.

Clinical Miscellany. The Mary Imogene Bassett Hospital, Cooperstown. Vol. II. Cloth. Price, $3.00. Pp. 218, with illustrations. Springfield, Illinois: Charles C Thomas, 1935.

Kathodenstrahloszillographie in Biologie und Medizin. Von Dr. Ing. Wolfgang Holzer, Assistent am physiologischen Institut der Universität Wien. Cloth. Price, RM 10. Pp. 155, with 74 illustrations. Wien: Wilhelm Maudrich, 1936.

L'Action des rayons ultra-violets et des rayons X sur les nerfs périphériques. Par Jacques Audiat, Docteur des Sciènces. Prèface du Professeur A. Strohl. Paper. Price, 25 fr. Pp. 88, with 33 illustrations. Paris: Masson et Cie., 1935.

L'Action biologique des rayons X et γ. By Paul Reiss, Professeur agrégé à la Faculteé de

Strasbourg. Tome 2.—Fascicule 2 du Cours de Physique Biologique, publié sous la direction de Fred Vlès, Professeur à la Faculté de Médecine, Directeur de l'Institut de Physique biologique, Université de Strasbourg. Paper. Price, 45 fr. Pp. 264, with 84 illustrations. Paris: Vigot Frères, 1935.

Kurzwellentherapie. Von Dr. Josef Kowarschik, Primararzt und Vorstand des Institutes für physikalische Therapie im Krankenhaus der Stadt Wien. Paper, price RM 9.60; bound, RM 10.80. Pp. 140, with 147 illustrations. Wien: Julius Springer, 1936.

Report of the Director of the School of Tropical Medicine of the University of Puerto Rico, under the auspices of Columbia University, For the Year Ending June, 1935.

The Liverpool Medico-Chirurgical Journal, 1935, *43*, Part 1. Hugh Owen Thomas Centenary Number.

Vol. 35, No. 4

DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., M.S., 105 Rutledge Ave., Charleston, S. C.

AN ECONOMICAL PROCEDURE IN ROENTGENOGRAPHY OF THE NASAL SINUSES*

By H. H. HOOK, R.T.
MADISON, WISCONSIN

THE roentgenographic projection of the nasal accessory sinuses for medical diagnosis should be considered from a theoretical, practical and diagnostic aspect. Economy of operating cost and expense to the patient also enter into these considerations. The purpose of this article is to discuss these problems from a technical standpoint in their proper sequence and outline a procedure which will insure maximum diagnostic quality.

It is desirable to demonstrate as many of the accessory sinuses in three dimensions with as little distortion as possible. The maxillary, ethmoid, sphenoid and frontal sinuses may be shown individually in posteroanterior and lateral positions on one 8″ × 10″ film. Duplication of positions at later examinations for progressive changes is readily accomplished by the simple apparatus to be described.

With fine focal spot tubes, it is possible to produce very fine detail. However, since the quality of a film is judged by visual evaluation, it will be necessary only to produce definition of sufficient fineness beyond which there will be no perceptible increase. For practical purposes it has been demonstrated that a 3 mm. focal spot tube will produce films of the same degree of diagnostic value as will the 1.5 mm. focal spot tube when intensifying screens and a

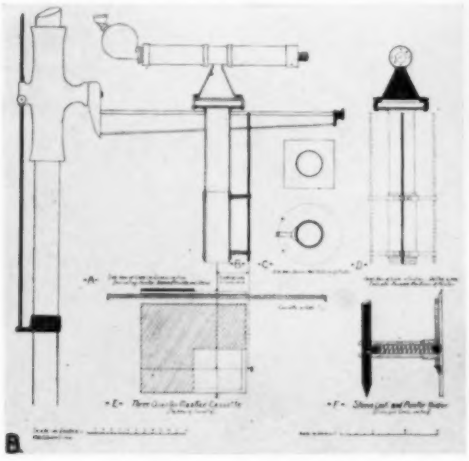


Fig. 1

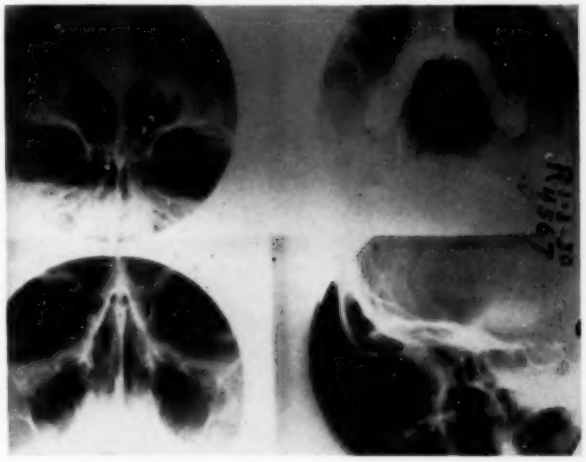


Fig. 2

Fig. 1. *A.* Side view of cone in cross section, indicating pointer sleeve. *B.* Center of cone to pointer, 10 cm. *C.* End view shows 360° rotation of pointer. *D.* Open view of cone in position; dotted lines indicate possible positions of pointer. *E.* Three-quarter masked cassette, top view. *F.* Sleeve lock and pointer holder, enlarged. Fig. 2. Roentgenogram of nasal sinuses.

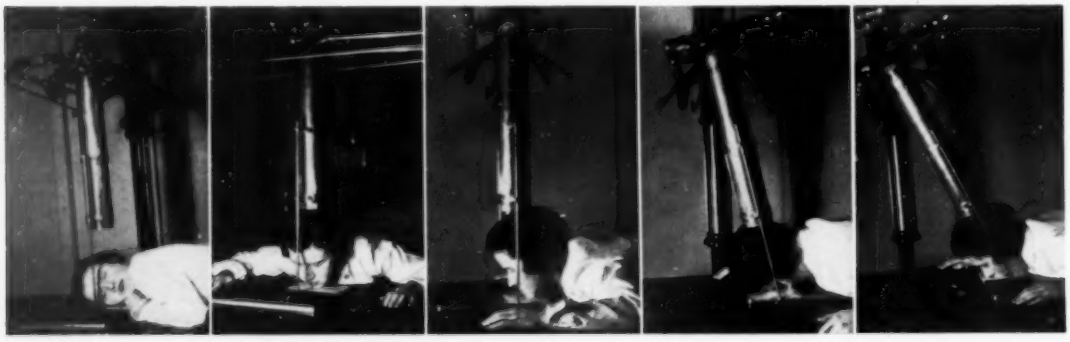
* From the Department of Radiology, State of Wisconsin General Hospital, Madison, Wis.

36 inch focal-film distance are used. The larger tube will have many practical advantages over the smaller one.

The first factor in any roentgenographic procedure to be considered is the inability of the patient to cooperate. Lack of detail is most commonly caused by involuntary motion and the physical factors responsible for magnified distortion. A short anode-film distance or the use of the Potter-Bucky diaphragm which increases the part-film distance materially contributes to the magnification of the part and definition.

By using the technique described and employing the accessories illustrated, it is possible to obtain four views of the sinuses and to duplicate the positions using one 8″ × 10″ film. The cone shown in Figure 1 is 3 inches in diameter and 19 inches long. permitting an anode-film distance of 36 inches. If instead of a 3 mm. focal spot tube a 4 mm. focal spot tube is used a slightly visible difference in the end-result will be observed. The films with this larger tube are of good diagnostic value; a detailed discussion of this problem will be published later. With the 3 and 4 mm. focal spot tubes it is possible to use tube currents of 75 to 100 ma., one second exposure time with 65 to 70 kv. on valve tube machines with full wave rectification. The smallness of the diameter of the cone together with the low voltage will produce a commendable degree of contrast in the roentgenogram (Fig. 2). Duplication of positions and centering is accomplished by the localizing device mounted on the side of the cone (Fig. 1).

The lateral projection is shown in Figure 3*a*. The cone is centered to the portion of the cassette to be exposed and to the outer canthus of the eye. The indicator should be perpendicular to the sagittal plane of the face and parallel to the supraorbital margins. The pointer is centered to the cassette as shown in Figure 1 (*E*, 1 and 2). The position for the maxillary antra, the chin is placed on the line *E*,1 as shown in Figure 1, and bisecting the face in the sagittal plane which is perpendicular to the plane of the cassette (Fig. 3*b*). The cone is centered over the vertex of the head and the central beam projected, as indicated in Figure 3*c*, through the alveolar process of the maxilla to the center of the exposed portion of the cassette. The frontal sinus position is shown in Figure 3*d*. The sagittal plane of the head is perpendicular to the plane of the cassette and centered on line *E*,2 with the supraorbital margins on line *E*,1. The cone forms an angle of 12° from the vertical plane, tilted towards the feet, and the central beam is projected through the lambda to the glabella. In the position for the sphenoid sinus as illustrated in Figure 3*e*, the open mouth is placed over the center of this portion of the cassette. The sagittal plane of the head is perpendicular to the plane of the cas-



a *b* *c* *d* *e*

Fig. 3. Demonstration of positions.

sette and centered on line *E*,2, the corners of the mouth on line *E*,1. The tube forms an angle of 24° from the vertical plane, tilted towards the feet, and the central beam is directed through the lambda to the corners of the mouth.

Any standard position may be used in either the horizontal or vertical projections of the sinuses. The marker is placed on the film between the lateral and the sphenoid positions. The value of this procedure may be summarized as follows:

1. The nasal accessory sinuses may be shown in three dimensions on one 8″ × 10″ film.

2. It produces the maximum diagnostic quality with a minimum stress on the roentgen tube.

3. Duplication of results to facilitate comparison of progressive changes is possible with the simple and inexpensive apparatus described in the paper.

4. The apparatus and procedure are applicable to any published technique.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

Farberow. Röntgendiagnostik der Tumoren der Gegend der Sella turcica. (The roentgen diagnosis of tumors in the region of the sella turcica.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Nov., 1934, *50*, 445–465.

Farberow emphasizes the fact that the roentgen diagnosis of tumors in the region of the sella turcica, a matter of vast clinical importance, may be very easy or may, on the other hand, severely tax the ability of the roentgenologist. The main and deciding point in many questionable cases is whether the sella is normal or not. The technique under which the roentgenogram is to be made should be standardized and meticulously followed. The author points out the changes in the sella which are produced by intrasellar, extrasellar, suprasellar and infrasellar tumors, and points out the importance small changes or even indirect signs may have in localizing a growth. Oftentimes roentgen findings must be supplemented by clinical and ophthalmologic findings for a certain diagnosis. The importance of the roentgen examination is illustrated by 23 roentgenograms in the text.—*E. T. Leddy.*

Haas, L. Einzelheiten aus der Röntgendiagnostik der Sella turcica. I. Über die sella konturen. II. Über die Grossenbestimmung der Sella turcica. (Some detailed considerations of the roentgen study of the sella turcica. I. The contour of the sella. II. The determination of the size of the sella turcica.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Nov., 1934, *50*, 465–467; 468–469.

Part I. Three contours of the dorsum sellae may be produced according to the anatomy of the sella and the method of projection of the sella. Contours in addition to these three typical ones are not necessarily pathologic. The base and anterior wall of the sella do not usually have a multiple outline but variations in it are not always pathologic. Haas gives anatomic and roentgenographic explanations for this finding. The dorsum sellae is best brought out by the nucho-frontal position of the author.

Part II. The author's method for determining the size of the sella is a development of those of other authors. The author explains the difference in the figures of actual measurements as due to the method by which the outline of the sella was obtained. In making measurements it is important to select the middle shadow of the dorsum sellae and not the lateral outlines and to eliminate for the measurements all extra sellar objects, for example, the projection of the clinoid processes.—*E. T. Leddy.*

Kovacs, A. Untersuchungen über die Sellagrösse nach Haas bei Kindern und bei Erwachsenen. (The size of the sella of children and adults as determined by the method of Haas.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Nov., 1934, *50*, 469–482.

Kovacs investigated 650 individuals to determine the size of the sella turcica. He points out that the differences in the size of the sella as estimated by various authors are probably due to differences in the methods of measurement. Some of these errors he illustrates by photographs and roentgenograms of autopsy specimens. The author illustrates by a curve the difference in size as obtained by the methods of Haas, Steiert, Sartorius, Wieser, and and Schulze. The author then gives figures for the normal sella of an adult, in children and in babies and points out the relationship between the size of the sella and the size of the head and of the pituitary and sella as shown roentgenographically.—*E. T. Leddy.*

Lüdin, M. Veränderungen der Sella turcica bei Sellafernen intracraniellen Tumoren. (Changes in the sella turcica in intracranial tumors at a distance from the sella.) *Acta radiol.*, 1935, *16*, 48–50.

Changes in the sella turcica may occur in tumors at a distance from the sella as well as in tumors of the hypophysis. These may produce the changes called "pressure sella," consisting of dilatation of the sella and erosion and atrophy of the bone. They are caused by increased intracranial pressure.

The author describes 4 cases in which such changes occurred in tumors at a distance from the sella. Three were endotheliomata of the

dura and the fourth a cystic glioma of the cerebrum. There was dilatation of the third ventricle in only one of them, which shows that enlargement of the sella can be brought about by generally increased intracranial pressure without dilatation of the third ventricle. In all 4 cases there was bilateral choked disc which rarely occurs in tumors of the hypophysis.—*Audrey G. Morgan.*

Cardillo, Furio. Le neoplasie secondarie della volta cranico dal punto di vista radiologico. (Secondary tumors of the vault of the skull from the roentgen point of view.) *Radiol. med.*, March, 1935, *22*, 205–224.

The author divides these tumors into three groups: those originating from the scalp, those originating inside the skull and metastases from distant tumors. Malignant epithelial tumors of the scalp are by far the most frequent cause of tumors of the skull. They are generally of the prickle cell type. It is generally hard to detect the beginning of the invasion of the bone roentgenologically. If the erosion has not involved the entire thickness of the bone the best projection to use is a tangential one. Sometimes it is possible with such a projection to detect tumors that have involved only the external table, and in the case of metastases from distant tumors sometimes metastases involving only the diploë can be detected. In these tumors which invade the skull by contiguity from the scalp the focus is always solitary; its edges are generally regular or slightly jagged, but almost always sharply defined at all stages. The invasion is always destructive; there is never any new production of bone or calcareous condensation. The invasion of the skull, even if extensive, may not cause any other symptoms than those already caused by the tumor of the scalp. There are rarely any symptoms due to lesions of nerve centers. Death generally results from sepsis caused by breaking down of the external tumor.

In the second class of cases, meningiomas, originating inside the skull the erosion of bone is not, as in carcinoma, a transparent area with sharply defined outlines, but an area of thinned bone with a spongy or spotted appearance and irregular and not clearly defined outlines. This is because it invades the bone through the Haversian canals, dilating them and finally destroying the separating laminae. In addition to these areas of erosion there is often an accentuated vessel outline in the form of dilated and tortuous sulci around the area of invaded bone.

Metastatic tumors of the skull may be of any type. They are rather rarer than metastases of other bones. Hypernephromas and malignant tumors of the thyroid seem to show a special tendency to invade the skull. The roentgen appearance of these metastases is more varied than that of the tumors that invade the skull by direct propagation. There is generally not a single focus but a more or less diffuse involvement; the individual lesions do not reach the size of those in the other types of tumor. In addition to the destructive lesions in this type of tumor there may be zones of eburnation. Metastases from carcinomata of the prostate and breast are particularly apt to show this eburnation.

Tumors by direct propagation rarely come for examination until late when the clinical picture is characteristic and the only task of the roentgenologist is to determine the extent to which the skull is involved. But it may be necessary to differentiate metastatic tumors from a number of other conditions, including Schüller-Christian's disease, circumscribed osteoporosis, occasionally tuberculosis or acquired syphilis, lymphogranulomatosis or Paget's disease. Differentiation by roentgen examination alone is extremely difficult if not impossible and the clinical picture must be carefully considered.—*Audrey G. Morgan.*

NECK AND CHEST

Gallavresi, Luigi. Studio radiologico delle ombre satelliti costali normali e patologiche. (Roentgen study of normal and pathological satellite shadows of the ribs.) *Radiol. med.*, April, 1935, *22*, 362–388.

In 1903 Albers-Schönberg called attention to the presence of a delicate elongated line about 2 mm. thick following the lower margin of the second rib. He called it the satellite shadow of the second rib. It was shown particularly well with his craniocaudal ventrodorsal projection; it was generally bilateral, only rarely monolateral. Other authors have found similar shadows accompanying the first rib, and more rarely the third rib. These shadows lie in the apical field. Similar shadows have been described also in the lower lung fields.

Albers-Schönberg said it was hard to interpret these images but that the satellite shadow of the second rib was probably caused by compact tissue above the apex. Knutsson

attributed them to the intrathoracic musculature. The author believes that the pleura, as well as the musculature is a factor in their production.

Among 850 roentgenograms of normal and pathological subjects he found such satellite shadows in 46 cases; he counted as positive only cases in which the shadows were very clearly defined. Among these 46 cases 29 were in normal individuals and 17 in those with various lung diseases. He studied the relationship of the shadows to pathological conditions and illustrates his conclusions with roentgenograms. He concludes that there are no changes in the shadows that are characteristic of definite diseases but there is a certain parallelism between changes in the shadows and the nature of the pathological process. Changes in the outlines of the shadows are more frequently seen in productive, infiltrative and cicatricial processes than in simple effusion into the pleural cavity in which the pleura is not affected. In simple effusion, however, the shadows may be thicker and longer than usual but without changes in form. A comparison of the shadows on the two sides may be significant. Festooning or serration of the edges of the shadows indicates a pathological process. The only exception to this rule is the characteristic triangular form of the shadows in accessory lobes. Shadows which appear in unusual locations are indicative of pathological processes.—*Audrey G. Morgan.*

Reichle, Herbert S., and Moritz, Alan R. Subacute peribronchiolar pneumonia. *Am. J. Dis. Child.*, Nov., 1934, *48*, 1001–1014.

Subacute peribronchiolar pneumonia is a disease of infants. The following are the cardinal signs and symptoms: (1) a persistent cough which is productive, paroxysmal and extremely debilitating; (2) an absolute increase in the volume of the lung due to a generalized emphysema; (3) the presence of fine râles which are heard more or less constantly, at times diffusely throughout the chest and at times localized and migratory; (4) inspiratory retractions of the epigastrium, intercostal spaces and suprasternal notch; (5) a history of a progressive respiratory ailment of at least four weeks' duration, associated with cough, cyanosis and pallor and dyspnea. Fourteen patients are included in this study and report.

The disease has no characteristic curve for temperature. A normal or slightly elevated temperature is present at irregular intervals. Frequently the temperature drops to subnormal levels just before death.

Post-mortem examinations show that peribronchial and peribronchiolar pneumonia is an invariable feature of the disease. Diffuse pneumonias may occur late and are the precursors of death. Sinusitis and otitis media are common complications. Parenteral dyspepsia is frequently seen. Edema developed in 5 of the patients studied. Renal function showed no impairment. No vascular collapse or cardiac decompensation was noted.

The prognosis is poor. The white cell count is not characteristic. The roentgenogram may show no other changes than those of emphysema. The pulmonary fields are dark; the ribs are usually in a position of extreme inspiration, and the arc of the diaphragm is depressed and flattened. The hilar shadows and the pulmonary markings may be increased in density, a finding which may be characteristic of nothing more than a bronchitis. The markings are particularly dense about the cardiac shadow. In 2 instances in the study, there were dense shadows at the right cardiac border which postmortem examination revealed in one case to be due to an atelectatic middle lobe of the right lung and in the other to an interlobar pleurisy. Early stages of the disease, however, are characterized by relatively slight roentgenologic findings in the face of serious pulmonary signs and symptoms.

Post-mortem examinations in 8 children showed subacute and chronic bronchiolitis, peribronchial pneumonia, bronchiolectasis and emphysema. The bronchiolitis was obstructive by reason of either mucosal swelling and intrabronchiolar exudate or organization of intrabronchiolar exudate with consequent obliteration. During the more acute phase of the inflammation in a given bronchiole the process was destructive and exudative with especially severe damage to the musculo-elastic elements of the walls of small air passages and resulting ectasia. In the later stages of the inflammation the process was productive with resulting peribronchiolar induration. Concomitant with the obstruction of air passages, peripheral distention, emphysema and atelectasis appeared to depend on the completeness and duration of the bronchiolar obstruction. Emphysema was characteristically predominant.

The conditions to be differentiated are bronchopneumonia and so-called migratory

pneumonia. The latter do not show repeated or continuous respiratory infection in the history, irritating, productive or exhausting cough, and a generalized nature of the process. Foreign bodies and pertussis must also be ruled out in the diagnosis.

Little can be said concerning the etiology of the disease. It is probably a respiratory infection caused by common microorganisms, which localizes at a site that has mechanical disadvantages for an infant otherwise possessing considerable resistance.—*R. S. Bromer.*

Cola, Giuseppe. Osservazioni radiologiche nelle pericarditi acute e croniche. (Roentgen observations in acute and chronic pericarditis.) *Radiol. med.*, Feb., 1935, *22*, 125–146.

Seven cases of acute and chronic pericarditis are described and illustrated with roentgenograms. In connection with these cases the author discusses the difficulty of clinical diagnosis of pericarditis and the great value of roentgen examination. He uses the word synechia to indicate simple adhesion of the folds of the pericardium to each other, periechia to indicate that the heart is surrounded by a fibrous shell of varying degrees of resistance which may become calcified, constituting armored heart. Prosechia means fixation of the pericardium to adjacent parts; it may be anterior, to the wall of the thorax, posterior to the spinal column, inferior to the diaphragm or to the right or left lung. Cardiocatechia means fixation of the heart in such a way that its rhythmical movements are interfered with.

In fibrinous or dry pericarditis sometimes the pathognomonic clinical sign of friction is not present and roentgen examination confirms the clinical suspicion by showing the heart not enlarged, with reduction or disappearance of pulsations and paresis or paralysis of the left half of the diaphragm. In serofibrinous pericarditis roentgen examination may show beginning intrapericardial effusion even in a very early stage of the disease. In such cases Holmes' maneuver, that is, observation of changes in the outline of the heart on change of position of the patient, shows a characteristic deformity of the left outline between the upper and middle arches. With increase of the effusion the picture becomes quite characteristic; the heart assumes a spherical form similar to a squat bottle with a short neck, the outlines are very convex, the normal subdivision into arches disappears and the transverse diameter is increased. The shadow of the superior vena cava is enlarged, the pulsations of the heart are abolished and the diaphragm is paretic and immobile. The best method of studying cardiac effusion is by roentgen kymography, and in some cases with the method of gastric insufflation recommended by Maragliano.

In some cases there is a double outline on the right or a central nucleus that is more opaque. This is rather rare but does occur both in children and adults. Holmes' maneuver with demonstration of broadening of the base and decrease of the transverse diameter serves to differentiate pericardial effusions from large myocarditic hearts. In myocarditis the heart assumes a triangular form with rather rectilinear outlines with weak and irregular pulsations that can easily be identified on roentgen kymography and Holmes' sign is lacking.

In simple synechia in addition to the possible existence of calcareous concretions roentgen examination may show signs of cardiocatechia. In periechia the roentgen signs are still more marked. The heart is enlarged, the superior vena cava broadened, the heart pulsations are invisible or only slightly visible, the normal movements of rotation on the axis and advancement of the apex during systole are not seen, the heart is rigid and does not change form on respiration. In addition to this, roentgen kymography shows that there is no increase of the contractions of the heart on effort.

In prosechia the roentgen symptomatology is still more abundant and more constant. The heart is small with irregular outlines, the superior vena cava is enlarged, the pulsations are reduced or abolished, the diaphragm is fixed and festooned. There are often signs of mediastinal pleurisy. The precardiac and retrocardiac spaces may be reduced or opacified and do not clear up on respiration. An important sign of cardiocatechia is that the outlines of the heart do not change during respiration. The roentgen study is completed by a study of Wenckebach's profile, demonstration of changes in the play of the diaphragm and possible demonstration of diverticula of the esophagus from traction.—*Audrey G. Morgan.*

Kienböck, R., and Weiss, K. Über das entzündliche Herzbeuteldivertikel. (Inflammatory diverticula of the pericardium.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1934, *50*, 442.

The authors report a second case of this condition. In cases of an indefinite cardiac

lesion where the roentgenogram shows a round or oval cystic mass near the right border usually, of the heart, a diagnosis of inflammatory pericardial diverticulum with chronic adhesive pericarditis can be made. The authors present roentgenograms of their two cases.—*E. T. Leddy.*

Cola, Giuseppe, and Lo Monaco, Giovanni. Saggi di radiochimografia polmonare (Roentgen kymography of the lungs.) *Radiol. med.*, April, 1935, *22*, 297–311.

Roentgen kymography is a method of examination by means of which the movements of internal organs are registered graphically. It was first used by Gött and Rosenthal in 1912 in the examination of the heart. Stumpf improved the method.

The authors have used it in a series of lung conditions which they describe and illustrate with roentgen kymograms. The movements of the ribs and diaphragm are registered.

In tuberculosis of the hilus glands there is defective function of the diaphragm, probably from compression of the phrenic nerve. In tuberculosis with cavity formation it is easy to determine whether the cavities are affected by the movements of the ribs or diaphragm, which gives valuable indications for treatment. In a large percentage of cases of lobar pneumonia there is decreased movement of the diaphragm on the affected side. In exudative tuberculosis there was no change in the mechanics of respiration, probably because there were no pleural adhesions. In pulmonary abscess without pleural adhesions there was no change in the mechanics of respiration. In adhesive pleurisy there was always reduced movement of the ribs and reduction or abolition of the movements of the diaphragm on the affected side. In exudative pleurisy roentgen kymography did not show any change in the movements of the ribs of the affected side; the liquid level followed the movements of the ribs. In excision of the phrenic nerve the diaphragm showed very much reduced active and passive movements on the treated side while the upper ribs on that side generally move with greater intensity than on the other side. In partial anterior thoracoplasty with apicolysis the lung may maintain its respiratory movements synchronous with those of the walls of the thorax. Some months after pneumothorax with low pressure, there was a complete recovery of function of the diaphragm in some cases.

The authors think the method will prove a valuable supplement to clinical and ordinary roentgen examinations both from the scientific and the practical point of view.—*Audrey G. Morgan.*

ABDOMEN

Rigler, Leo G. The roentgen diagnosis of small carcinomata of the stomach. *Wisconsin M. J.*, April, 1935, *35*, 236–241.

Rigler discusses the failure of adequate therapy in gastric cancer, emphasizing the inability of the average physician to recognize the lesion in its early stages. The only sure method for such early diagnosis is by the roentgen ray. One of the most difficult and exacting of roentgen examinations, it is, nevertheless, in competent hands and under favorable conditions, an amazingly accurate procedure. However, the roentgenologist rarely has the opportunity to test his skill in the discovery of very early malignancies, the usual case being rather advanced when first seen. Two cases in which very small carcinomata were diagnosed by roentgenological study are reported and the differential diagnosis is discussed.—*W. R. Brooksher.*

Gray, Howard K., Balfour, Donald C., and Kirklin, B. R. Cancer of the stomach. *Am. J. Cancer*, Oct., 1934, *22*, 249–286.

This article is a review of the literature plus a summary of the experience of the Mayo Clinic in dealing with carcinoma of the stomach. In discussing the etiology the authors agree with Bloodgood that chronic gastritis may become malignant and that it is impossible to distinguish between simple gastric ulcer and early cancerous ulcer. In a study of 373 cases two distinct clinical groups were recognized: the larger group was composed of patients whose symptoms had persisted for a varying length of time without remarkable change; 75 per cent of this group had experienced symptoms for less than one year and 40 per cent less than three months. In the second group were those patients who had experienced symptoms referable to the stomach for a varying length of time but who had noticed a recent change which was not similar to any previous complaint. This recent change in most instances consisted in the onset of obstructive features, hemorrhages, rapid loss of weight, anorexia or features suggestive of a large tumor. They found no syndrome characteristic of

malignant disease of the stomach. In 47 per cent of the proved cases of gastric carcinoma encountered at the Mayo Clinic, the history was that of the accepted syndrome of benign ulcer. They place little significance upon the determination of free hydrochloric acid in the gastric contents as a criterion on which to base the differential diagnosis of benign gastric ulcer, malignant ulcer or ulcerating cancer. The greatest aid to correct diagnosis in their experience was the roentgen examination. Carman found 95 per cent of gastric cancer gave roentgen evidence of their presence. Kirklin and Eusterman adopted the principle that a perforating ulcer with accessory pocket outside the stomach was benign, whereas an ulcer, the crater of which was surrounded by an elevated wall, was malignant. Niches larger than 3 cm. were found to be malignant in a high proportion of cases.

The treatment is either surgical removal of the lesion or surgical relief of the obstruction if the removal of the mass is impossible. Discussion is given of the preoperative and postoperative care of these patients. The operative procedure is described in detail and illustrated by 11 figures.

The pathology is discussed. They found the most common site of metastatic lesions to be in the neighboring lymph nodes, principally the nodes of the subpyloric group, the liver, the rectal shelf and the umbilicus. In addition, the supraclavicular lymph nodes, the ovaries, lungs, brain, spinal cord, kidneys and bones may be involved.

The patients with a short history were given the gravest prognosis. The three factors leading to a short postoperative life were involvement of lymphatic structures, serosal involvement and malignancy of high grade.

In the analysis of 1,000 cases in reference to end-results it was found that 52 per cent of patients without lymphatic involvement were alive three years while only 19 per cent with such involvement lived that long.

As an appendix to the article Kirklin gives a brief summary of the roentgen diagnosis of gastric carcinoma.

An extensive bibliography is given.—*J. H. Harris.*

Wilson, J. Allen, and Noble, John F. An instance of gelatinous carcinoma of the duodenum. *Am. J. Digest. Dis. & Nutrition*, Feb., 1935, *1*, 840–844.

The incidence, pathology and clinical evidences of duodenal cancer are discussed. As major symptoms, flatulence, pain or distress after eating, retention type of vomiting, dehydration and toxemia, are mentioned. Nearly all writers describe an intermittent jaundice as typical of peri-ampullary carcinoma. In the first portion of the duodenum, diagnosis is rarely possible of differentiation from that of obstructing carcinoma of the pylorus. The authors' case of gelatinous carcinoma of the duodenum with necropsy findings is reported in detail.—*W. R. Brooksher.*

ROENTGEN AND RADIUM THERAPY

Ostrcil, Ant. Les résultats de la radiumthérapie du cancer utérin. (Results of radium therapy in uterine cancer.) *Cahiers de radiol.*, Jan., 1932, No. 7, 145–148. Supplement to No. 2, Jan. 15, 1932, *Gaz. méd. de France.*

A. Cancer of the uterine cervix. Cancer of the cervix is divided into four stages, conforming to the principles of the Cancer Committee of the League of Nations as expressed in its report of June, 1929. If the cancer is ulcerated and there is elevation of temperature, a preliminary treatment with vaginal irrigations of chloramine solution is instituted. Otherwise, the procedure is as follows: First a sort of curettage is practised, consisting in ablation with a blunt spoon of all the accessible masses of the tumor, the so-called excochleation. Then the cervix is cauterized and radium inserted. All this is done in the operating room under absolute aspetic conditions and with the aid of ether anesthesia. The technique of the radium application consists in the insertion within the fundus and the cervix of three tubes of element filtered with 2 mm. platinum and inclosed in rubber, the first tube containing 10 mg., the second 20 mg. and the third 10 mg. of radium element. In addition, two tubes of 10 mg. each inclosed in a rubber pessary are placed in the cul-de-sacs. The total amount is left in situ for 100 continuous hours, thus making 6,000 mg-hr. For the past five years the author has supplemented this treatment with an injection of silver emulsion (prepared with an oil activated by emanation) in the parametria, and the parauterine tissues, to block as much as possible the remaining cancerous cells. The tissues are injected in a manner similar to that employed in local anesthesia. The metallic oily solution,

which is prepared by the Kolin Manufacturing Company, contains 0.1 gm. silver or 0.1 gm. tungsten in 1 c.c. and is activated by the emanation which is added to 10 to 50 c.c. of the emulsion. Of course the emanation loses its activity according to the exponential law, but a deposit of radium D will remain in the tissues for a long time, its period of half transformation being equal to 16½ years. The radium D emits beta and gamma rays and one therefore might expect that the beta rays after impinging upon the small metallic particles will provoke a new secondary beta radiation which will have a particularly efficacious effect on the cancerous cells.

In dealing with the subject of interstitial injection of metallic emulsions, the author experimented on rabbit ears by using first an emulsion without activity, second, an emulsion with very efficacious activity, and third, a pure oil without metal but activated. The results of these experiments will be published later.

In carcinoma of the cervix when the lesion has advanced to Stage 2, 3 and 4, deep roentgen therapy is given in addition to the above treatment. The technique is: 180 kv., 4 ma., 0.5 mm. copper, 1 mm. Al filters, 30 cm. distance, 2 anterior and 2 posterior fields, 10×15 cm. in size, 0.92 copper half-value layer, 100 per cent S.U.D. (750 R) over the individual field, the depth dose at 12 cm. below the skin being about 25 per cent.

The aim is to administer the entire treatment in one series. If later repetition of the treatment should prove necessary, the response to the successive series becomes less and less pronounced.

The author tabulates the results in some 190 cases, the time of observation extending from one to five years. In the five-year cases, the percentage of relative cure (Stage 1 and 2) was 50 per cent and the percentage of the absolute cure (Stages 1, 2, 3 and 4) was 44 per cent, a truly remarkable result.

B. Cancer of the uterine body. In this group, certain cases are operated upon but the majority are, as in cancer of the cervix, submitted to intrauterine application of radium followed by roentgen therapy. The procedure is practically the same as in carcinoma of the cervix, except that each of the three intrauterine tubes contains 20 mg. of radium, the total radium thus amounting to 80 mg., which is used for a dose of 6,000 mg-hr. The injection of the parauterine tissues with the radioactive emulsion is omitted, inasmuch as the carcinoma of the body of the uterus does not extend by the route of the lymphatic vessels or parametrium. Following the application of radium, roentgen therapy is immediately started with a technique such as described above. The results obtained were likewise very satisfactory.—*T. Leucutia.*

Podesta, Vittorio. La radioterapia nel trattamento delle affezioni tubercolari degli organi genitali dell'uomo e della donna. (Roentgen therapy of tuberculosis of the genital organs in men and women.) *Radiol. med.*, Oct., 1932, *19*, 1133–1151.

The author has been using roentgen treatment for tuberculosis of the genital organs in both men and women for the past ten years. He reviews the literature of the subject and discusses his own results in a large number of cases. He has had good results from the use of doses of from 25 to 60 per cent of a skin erythema dose. He believes in the use of small or moderate doses but not the very small doses that have been recommended by some authors. In men he has irradiated not only the testicles but also the prostate, seminal vesicles, etc. In both men and women he irradiates six portals of entry through the pelvic girdle, three behind and three in front. He says that the roentgen method should be used in close cooperation with surgery. Surgical treatment should be given preference only in cases in which the diagnosis is certain and the lesions are strictly circumscribed and there are not serious complications in other organs. He also believes in postoperative irradiation and thinks roentgen treatment should be supplemented by medical, dietetic and climatic treatment.—*Audrey G. Morgan.*

Lacassagne, A. Resultats obtenus à l'Institut du Radium de Paris en radiothérapie des cancers du rectum. (Results obtained at the Radium Institute of Paris in radiation therapy of cancer of the rectum.) *Radiophys. et radiothérapie*, Volume 2, No. 4, 577–585.

The average surgical statistics indicate that 50 per cent of the cancers of the rectum are already inoperable when coming for examination, and that the surgical mortality constitutes another 25 per cent, so that a five-year cure, discounting the patients who die from recurrence, reaches hardly 12 per cent. Still this percentage is considerably better than that obtained with

any form of radiation. Thus at the Radium Institute of Paris 49 cases of cancer of the rectum were treated between 1919 and 1929, none of which were cured. According to treatment, the patients were divided into five groups: (1) those with intra-cavitary curie therapy; (2) those in which radium puncture; (3) those in which association of radium with surgery; (4) those in which transcutaneous curie therapy, and (5) those in which roentgen therapy was used. Regardless of the technique employed only temporary results were obtained.

In addition to the above cases, 8 cases of carcinoma of the anus were treated during the same period. Here in 4 cases favorable results were obtained by curie therapy so that for this type of lesion irradiation is advocated as the method of choice.—*T. Leucutia.*

Roffo, A. H., and Carranza, F. Resultados del tratamiento del cáncer de recto obtenido en el Instituto de Medicina Experimental. (Results of treatment of cancer of the rectum obtained at the Experimental Medical Institute.) *Bol. Inst. de med. exper. para el estud. y trat. del cancer*, 1931, *7*, 368–381.

Sixty-eight cases of cancer of the rectum have been treated at the Experimental Medical Institute of Buenos Aires during the past five years. These cases are reviewed in the light of incidence, family history, microscopic appearance, etc. The treatment of choice was surgical intervention, a colostomy having been performed before the operation. Curie therapy and roentgen therapy must be considered as only palliative methods. In the inoperable cases diathermic coagulation is used, followed by radiation therapy.—*T. Leucutia.*

MISCELLANEOUS

Case, James T. The teaching of radiology to interns. *J. Am. M. Ass.*, March 19, 1932, *98*, 936–938.

In most hospitals radiologic instruction given to the interns is desultory and not under definite check. The intern is permitted to absorb radiologic knowledge in the course of other training. Since the education of the physician in radiologic matters is important to the service of the patient and cooperation with the radiologist a definite program of instruction of interns should be formulated, the extent of the program being dependent on the size of the hospital and facilities for teaching.

Instruction should include: (1) the nature and origin of roentgen rays and of secondary radiation, and the physical and biologic laws that apply to them; (2) the scope of the roentgen examination with correlation of clinical and roentgen procedures; (3) roentgenoscopic control of reduction of fractures and dislocations and removal of foreign bodies; (4) roentgen interpretation and its relation to the clinical findings and history; (5) roentgen terminology; (6) the general principles of roentgen therapy with attention to selection of cases and limitations of the method.

Rotating interns should spend two or three months in the roentgen department and under no condition should an intern be allowed to enter upon the roentgen-ray field as a fellow until he has served his general rotating service. —*E. W. Hall.*

Johnson, Clayton R. A new method for roentgenographic examination of the upper end of the femur. *J. Bone & Joint Surg.*, Oct., 1932, *14*, 859–866.

Johnson presents a new method of roentgenographic examination of the upper end of the femur in the lateral position. He regards this method as particularly adapted to the study of fractures of the upper extremity. He is able to demonstrate, he states, that examination in the anteroposterior position is inadequate in detecting deformity which may be present following fracture and attempted reduction.

His method is as follows:

1. Construct from a heavy piece of cardboard an anglemeter in the form of a right-angle triangle, the angles of which are 90°, 65°, and 25°.

2. Have the patient in a supine position.

3. Place the cassette containing the sensitized film, parallel with the longitudinal plane of the shaft of the femur, inclining outward at an angle of 65° with the horizontal plane. Determine this angle accurately with the anglemeter. Center the cassette just above the margin of the greater trochanter.

4. Use target film distance of 36 to 40 inches with small cone which casts not more than a 1/8 inch circle of light on the cassette. Place the base of the anglemeter parallel with the longitudinal plane of the shaft of the femur, the altitude in the transverse plane of the femoral shaft, and the hypotenuse on the upper side, its plane passing through the upper margin

of the greater trochanter. Direct the central rays 25° toward the table and in line with the hypotenuse of the angle meter.

Johnson claims the advantage of this procedure is the ease of accomplishment at the patient's bedside or with the patient on a fracture table with the average portable apparatus. The patient need suffer no discomfort whatever from the examination which can be made entirely satisfactorily, regardless of the type of immobilization which may be present.—*R. S. Bromer.*

Drüner, L. Moderne Röntgenstereoskopie. (Modern roentgen stereoscopy.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Aug., 1932, *46*, 142–148.

In the development of stereoscopy three recent developments are of essential importance: (1) roentgenographic apparatus with automatic control; (2) the Potter-Bucky grid, and (3) the use of double coated films. A stereogram presents proper perspective only when both eyes of the observer are at the same position as the two local spots when the exposures were made. The greater the experience of the observer, the more is this insisted upon. There are four possibilities of uniting the spatial images of stereoroentgenogram: (1) to form an orthomorphic image (lateral orthographs); (2) to form a pseudomorphic image (pseudolateral orthographs), (3) to form an orthoscopic reflected image (reversed-lateral orthograph), and (4) to form a pseudoscopic reflected image (reversed-lateral pseudoscopic orthograph). Of the four methods, numbers 1 and 2 are preferable. The stereoplanigraph is the best developed and most generally applied method. But it may run into difficulties in some obstetrical applications. The simplest method of measurement is with a grid, which meets practical requirements.—*E. T. Leddy.*

Altschul, Walter. Vorläufige Mitteilung über die Wirkung von Radiumchloridinjektionen. (Preliminary report on the effect of radium chloride injections.) *Strahlentherapie*, 1932, *45*, 759–762.

After a general discussion of the effect of weak radium irradiations, the author reports his own work on the use of radium chloride injections. The method is indicated chiefly in those inflammations of muscles and joints that are generally called rheumatism. Good results are also obtained in gout, arthritis deformans and neuralgias, especially sciatica.

He gives a series of six injections with an interval of a day between each two injections. The first three injections are of 1 mc. each, the last three of 2 mc. This series is repeated after three weeks. Generally a third series is not necessary. If the symptoms recur after a considerable time another series may be given. Frequently these are cases of multiple disease and injections must be made at several places. The author has frequently given three injections at different places at the same sitting without any injurious by-effects. Because of the reaction produced by each injection, the injections should not always be made at the same place, but a distance of 1 cm. should be left between the sites of injection.

Illustrative cases of rheumatism and sciatica are described.—*Audrey G. Morgan.*

Sarasin, R. Un appareil simplifiant la technique d'administration des lavements opaques, spécialement pour la muqueuse. (An apparatus simplifying the technique of administration of opaque enemas, especially for the mucosa.) *Bull. et mém. Soc. de radiol. méd. de France*, May, 1932, *20*, 276–277.

The author constructed an apparatus consisting of a recipient of double reservoir, one of which contains the pure solution of thorium and the other the diluted solution. Compressed gas (oxygen, nitrogen or air) is made to act on the apparatus producing a pressure of from 0.3 to 0.4 atmosphere. A valve operated by a foot switch permits the alternating connection of the two reservoirs. The advantages consist in the fact that a good impregnation of the mucosa of the colon can be obtained by simply changing the dilution of the colloidal thorium and that the time of examination is greatly shortened.—*T. Leucutia.*

Dioclès. Technique simple pour l'étude radiographique et stéréo-radiographique des plis muqueux avec la diagnothorine. (Simple technique for the roentgenographic and stereoroentgenographic study of the mucous folds with diagnothorine.) *Bull. et mém. Soc. de radiol. méd. de France*, Jan., 1932, *20*, 44–50.

Diagnothorine is a colloidal liquid recently introduced in France, containing 25 per cent of thorium oxide. It is a clear, whitish, slightly

dichroic solution, of high density, neutral, inert, of slightly astringent taste and rather agreeable. It is practically non-toxic and it can be used for all examinations in quantities less than 100 c.c. The author employed the substance in a number of cases for the study of the mucosal folds of the esophagus, stomach and duodenum and obtained some very satisfactory results. Stereoroentgenograms have proved of great value.—*T. Leucutia.*

Adam, A. Kontrastmittel und Innenwanddarstellung des Verdauungstraktus. (Contrast media and visualization of the inner wall of the digestive tract.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, April, 1932, *45*, 385–396.

The author experimented with three opaque media generally used for the roentgen visualization of the mucosa of the gastrointestinal tract: (a) barium sulf. pur. Merck, which is administered in the proportion of 0.6–0.75 substance to 1 water (that is, 250 to 300 gm. to 400 c.c. water); (b) neobar, which is administered in the proportion of 1:1, and (c) lactobaryt, which likewise is administered in the proportion of 1:1. The experiments included a study of: (1) the optimum mixture; (2) the contrast effect, distribution of opaque medium and the flow of the emulsion, and (3) the penetration into the folds and the adherence. It was found that barium sulf. pur. Merck forms a thicker emulsion, the less water is added. If the proportion of the barium and water is 2:3 the emulsion is still very thick. Beyond that limit it becomes pasty. The usual thin emulsion when poured from a glass does not flow continuously but with formation of clumps, indicating a rather non-homegeneous distribution of the opaque substance. The adherence is very poor.

The neobar appears too thin in a proportion of 1:1. The consistency of lactobaryt emulsion is reached only when the proportion of the neobar to water is 280 to 150 (1.8:1). The preparation of neobar is quite difficult inasmuch as during mixing bubbles and foam form which impair the consistency, homogeneity and adherence. Its roentgen opacity, however, is superior to that of barium sulf. pur. Merck.

The lactobaryt forms the best mixture when the proportion is 1:1. The emulsion is very homogeneous and when poured flows like thick oil, containing no bubbles and producing no foam. Its preparation is very simple. Homogeneity, penetration between the folds and adherence are decidedly superior to that of both barium sulf. pur. Merck and neobar.

In a second series of experiments the author used five identical barium sulphate mixtures but varied the type and duration of mixing. He found that thus a great difference in the consistency was obtained. In endeavoring to explain this he studied the effect of the size of granules and of the surface suspension of the barium salts, but found that these had no noticeable influence on the distribution, consistency, penetrability between the mucosal folds and the adherence. A suspension of chemically pure barium sulphate, no matter of what granular size and of what surface suspension possessed the minimum of the above properties. In this respect one may say that the barium salts are very much inferior to other adherent preparations used for the relief visualization. Further experiments are necessary in order to find a more suitable medium.—*T. Leucutia.*

Leitner, Z. Experimentelle Studien zur Darstellung innerer Organe mit Thorotrast. (Experimental studies on the visualization of internal organs by means of thorotrast.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1932, *46*, 47–52.

Leitner reports some experiments he performed on rabbits. He shows that measurements of the organs even when made with an exact technique have a high error. It is shown that thorotrast is absorbed mostly by the liver and spleen and also by the spongiosa of the long bones, and by the marrow-containing bones to a considerable extent. By injecting large quantities of thorotrast the kidneys can be visualized due to the fact that thorotrast is excreted by the venous capillaries. The vascular system can be shown to a great extent because thorotrast is visible in the blood stream. The author is inclined to reject thorotrast for use in man because it is too dangerous and harmful.—*E. T. Leddy.*

Heathcote, R. St. A., and Gardner, R. A. Abrodil: an experimental investigation. *Brit. J. Radiol.*, Dec., 1931, *4*, 641–651.

Conclusions. Abrodil, given intravenously in dogs up to 7 gm. per kilogram body weight, has been shown to be non-toxic. The speed at which the injections are made does not seem to be important.

The isolated heart and intestine of the rabbit are scarcely affected by solutions of abrodil of strengths comparable to those which might occur in man after administration of the normal dose.

Abrodil, in doses up to 3.33 gm. per kg., given intravenously, produces only minimal changes in the blood pressure. In larger doses, up to about 7 gm. per kg., a fall of blood pressure is produced, which is less pronounced and less prolonged than that previously described with uroselectan.

Up to 3.33 gm. per kg., abodil produces no appreciable effects on respiration. With increasing dosage, however, there is a progressive slowing of the respiration. Death is caused at about 8 gm. per kg. from asphyxia.

No pathological changes were observed to occur in animals which had received large doses, 7 gm. per kg., on one occasion, or which had been given 1.66 gm. per kg., daily for six days. Again, in the organs of animals previously rendered nephritic by uranium, there were found, following the administration of large amounts of abrodil, no changes other than those produced by the action of that metal. Abrodil is excreted by the kidneys of dogs rendered nephritic with uranium, though the rate of excretion is greatly reduced from the normal. As a result, the concentration in the urine may be less than that required to produce roentgen shadows. Abrodil is efficient in making the urine radiopaque and is a satisfactory medium for urography in dogs. It is superior to uroselectan in the speed with which it is excreted, the dose necessary for the production of roentgenograms and, in the dog at least, in their quality.—*T. Leucutia.*

Haxthausen, H. Axel Lauritz Reyn. *Acta radiol.*, Aug. 15, 1932, *13*, 197–200.

This number of the *Acta radiologica* is inscribed by radiologists of the Scandinavian countries to Axel Reyn on the 60th anniversary of his birth as an expression of their gratitude for his devoted work as a pioneer of light therapy. He is retiring from his position as senior physician of the department for skin diseases in the Finsen Institute to devote himself exclusively to administrative work. His professional life from the beginning has been devoted to the Finsen Institute and in 1900 he was married to Elisabeth Finsen, the sister of its founder, Niels Finsen. He made the Finsen-Reyn lamp which made it possible to give light treatments outside the Institute and was one of the first advocates of artificial light baths. The cures in lupus vulgaris were about 60 per cent with local phototherapy alone and have risen to about 85 per cent since the addition of general light baths to the local treatment. A list of Reyn's scientific publications is given.—*Audrey G. Morgan.*

Pohle, Ernst A., and Bunting, C. H. Studies of the effect of roentgen rays on the liver. *Acta radiol.*, May 15, 1932, *13*, 117–124.

The liver regions of 84 adult white rats were irradiated with filtered roentgen rays of two different effective wave lengths (18 and 0.34 Å) in graduated doses of from 600 to 2,500 r at one sitting. The animals were killed two, seven, eleven and thirty days after irradiation. The liver regions of 30 adult white rats were irradiated with doses of 2,000 r of either of the wave lengths mentioned above; the animals were killed one a day from one to thirty days after the irradiation. Six untreated rats kept under the same conditions served as controls.

The histological changes found were swelling of the cells, chiefly due to imbibition of serum and occasionally of fat, followed at a later period by atrophy, from which there was recovery eventually. These changes were probably due to interference with cell oxidation. Both the swelling of the cells and the atrophy occurred in two cycles, suggesting that the changes in the liver are similar to those in the skin.

Plates are given showing the histological picture of the changes.—*Audrey G. Morgan.*

Markl, Jaromir. Über die bei Ra-Bade—Emanationsbade—im Gewebe selbst wirksame Energiemenge. (The amount of energy active in the tissues in radium baths—emanation baths.) *Strahlentherapie*, 1932, *45*, 779–781.

In the discussion of the effect of baths with waters containing radium emanation Lazarus concluded that the amount of energy absorbed by the skin is below the threshold of biological activity and that therefore the effect of radium baths is the same as that of hot baths in general combined with a suggestive factor.

The author studied the question and concluded that inspiration of emanation, which some have claimed is of value, is an insignificant factor. He found, however, that absorption through the skin is sufficient to be effec-

tive. For some years he carefully plotted curves of the emanation content of the blood and calculated the energy expended in the tissue. He found values of 10^{-5} erg per cubic centimeter and second. Zwaardemaker found that to stimulate the function of a heart that was standing still on irrigation with a radium solution required $0.5-1\times10^{-6}$ erg per second and gram. The figures found by the author lie above this threshold biological value and therefore he believes that radium baths have an actual biological effect.—*Audrey G. Morgan.*

Salotti, Adelchi. Primi resultati di ricerche capillariscopiche, capillarigrafiche e tonometriche sulla azione di radiazioni di diversa lunghezza d'onda. (First results of capillaroscopic, capillarographic and tonometric studies of the action of radiations of different wave lengths.) *Radiol. med.*, Oct., 1932, *19*, 1100–1112.

The author says it is unnecessary to emphasize the importance of study of the capillaries in irradiation. In order to correct some of the defects inherent in the capillaroscopic method he has made repeated photographic records of the findings in series of observations of the same group of vessels and has observed the variations of tonus in the same capillaries. Illustrations of these capillarographic findings are given. The examinations were continued for several days after the irradiations.

He finds that the addition of capillarography and tonometry very greatly increases the value of capillaroscopic findings. The capillaries of the ear are particularly adapted for this study. He found that with practically erythema doses of both roentgen and ultraviolet rays there was vasodilatation. The vessels first become tortuous, then dilated and then increase in number by the formation of new branches. These develop from little buttons which appear along the course of a chief capillary. The roentgen rays act particularly on the deep branches while the ultraviolet rays affect chiefly the superficial capillaries. The ultraviolet reaction is in proportion to the dose administered and takes place more promptly than the roentgen reaction. There are great individual differences in both reactions, probably due to some individual biological factor.

The tonometric reactions always precede the capillaroscopic reactions and show decreased tonus; evidently the rays act immediately on the factors which control vessel tonus, whether or not these are under the control of the sympathetic nervous system. The Welsch test often in both normal and pathological cases did not show accordance with the degree of roentgen erythema and the author therefore concludes that it cannot be used as a means of biological dosage. A tonometric test would be preferable. In normal and pathological cases observed for twenty-one days he did not see the alternations of vasodilatation and vasoconstriction that have been reported by some authors. Such temporary spastic reactions may occur, however, in some pathological cases.—*Audrey G. Morgan.*

Eckel, P. Über den Einfluss der Grenzstrahlen auf Leukozytensturz und Blutbild. (The effect of borderline rays on the fall of leucocytes and on the blood picture.) *Strahlentherapie*, 1932, *45*, 525–537.

The author performed experiments on rabbits in an attempt to determine the effect of Bucky's borderline rays on the number of leucocytes and the causes of it. A preliminary experiment was made with the same treatment and diet of the animals but without irradiation. Five animals were then irradiated with doses of 1,200 r, 280 r, 500 r, 300 r, and 150 r. There was a definite decrease of leucocytes in all 5 animals which occurred within eight to ten minutes after the irradiation. The decrease in leucocytes was 40 per cent or more. Later there was a rise to more than the original values. The fall was independent of the dose given. The preliminary experiments did not show any special decrease of leucocytes.

Bucky attributes the decrease of leucocytes to stimulation of the autonomous nervous system by the rays. Before the author had had an opportunity to perform experiments on sympathectomized animals a patient came under his treatment who had had sympathectomy of the left foot performed for juvenile gangrene. He therefore irradiated the right and left thighs to see whether there would be a difference in the leucocyte picture on the two sides. A dose of 250 r was given (10 kv., 10 ma.). Curves are given showing the course of the leucocytes. There was a sharp decrease in the number of leucocytes on the normal side of about 35 per cent while there was nothing like so great a fall on the sympathectomized side. This supports Bucky's theory that the decrease of leucocytes is due to stimulation of the vegetative nervous system.

Attempts to test the effect of borderline rays on the Arneth hemogram were inconclusive.—*Audrey G. Morgan.*

Leistner, Kurt, and Berger, Horst. Über Röntgenapparate mit hochspannungs seitiger Spannungsregulierung (Sekundärregulierung). (A roentgen apparatus regulated in the high voltage circuit (secondary regulation).) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Aug., 1932, *46*, 204–216.

This type of apparatus has a much lower voltage drop and therefore, due to a lessened power loss, has a greater efficiency and an improved load factor. This is important where high load is required with a low voltage. In an apparatus regulated on the primary side the difference of the current curve with a moderate load may be 50 per cent contrasted with an apparatus controlled on the secondary side, with a high load. By inserting the regulator in the secondary side the current flowing through it is less, and so its action is more certain.—*E. T. Leddy.*

Hertwig, Paula. Die genetische Grundlagen der Röntgenmutationen. (The genetic foundations of roentgen mutations.) *Strahlentherapie*, 1932, *45*, 657–678.

The author discusses the transmission of hereditary characteristics through the genes which are localized in the chromosomes. Not only the individual genes but their totality, which she calls the genom or inherited substance, may be changed by external influences leading to mutations. Experiments are described which show that mutations are produced in *Drosophila* by roentgen irradiation. It is probable that the great majority of the changes brought about are undesirable ones. To demonstrate such a change in the mutation rate in man or other mammals would require a great deal of time and money but the Society for Research in Heredity, for which she is working, feels that enough work has been done to show that there is danger of pathological recessive genes being transmitted, the effect of which will not become evident for some generations. They think it their duty, therefore, to give a warning against any irradiation of the sex organs if there is any doubt of its benefit to the individual or if this treatment can be replaced by any other, and they give a special warning against the use of large doses as the danger increases with the size of the dose.—*Audrey G. Morgan.*

Thoraeus, R. A protection arrangement for the repacking of radium bombs. *Acta radiol.*, 1933, *14*, 215–218.

The small bomb used for teleradium treatment at Radiumhemmet has to be repacked frequently and it is necessary to protect the workers who do this work. The apparatus used for this purpose is described and illustrated with drawings.—*Audrey G. Morgan.*

Benner, S. Intensity distribution and dosage in teleradium treatment at Radiumhemmet. *Acta radiol.*, 1933, *14*, 207–214.

Recently a new teleradium treatment apparatus designed by Sievert was installed at Radiumhemmet. The author has examined the intensity distribution with this apparatus using the condenser chamber method. A water phantom previously used by Sievert was used for this purpose. It is described and illustrated. Two diagrams are given showing the results of his investigation. The square field with the radium distributed in four parts at the corners of the square was found to differ from the circular field chiefly in its greater lateral extension; the isodose curves on the skin were approximately circular regardless of the distribution of the radium.

A large number of observations have been made at Radiumhemmet with regard to the surface intensity of the small bomb, the radium content of which is generally between 1,000 and 2,000 mg., averaging about 1,500 mg. On the basis of the results a simple method has been worked out for correcting for the varying intensity per milligram radium element.—*Audrey G. Morgan.*

Miescher, G. Tierexperimentelle Untersuchungen über den Einfluss der Fraktionierung auf den Späteffekt. (Animal experiments on the effect of fractionating on the late effect.) *Acta radiol.*, 1935, *16*, 25–38.

The question of fractional roentgen irradiation was studied experimentally on rabbits' ears. The late tissue reactions after one to four years were studied rather than the immediate erythema, as it is the late effects that seem to be dangerous in human treatment. The effect was measured by the thresholds for growth of white hair (destruction of pigment function), permanent baldness, atrophy, necrosis and hyperkeratosis. Tables are given showing the details of the results. It was found that the increase in tissue tolerance and fractionating

are related to each other in a way that can be represented graphically and such graphs are given. They indicate that the lengthening of the intervals has relatively little effect. The partial dosage is the decisive factor. They indicate also that there are limits set to the increase of tissue tolerance by fractionating and that the present tendency to increase the total dosage more and more is not free of danger.—*Audrey G. Morgan.*

Kuhlmann, Fritz. Bedeutung und Wege der Röntgendiagnostik für die Erbforschung. (The importance and applications of roentgen diagnostic procedures in studies of heredity.) *Forschr. a. d. Geb. d. Röntgenstrahlen*, July, 1934, *50*, 91–93.

Kuhlmann points out the great importance roentgenology will have in the study of genetics and its great superiority over the usual postmortem methods. He reports a study he made of forked ribs in three generations of a family in which other anomalies of the ribs were found. He concludes that forking of the tips of the ribs is a recessive hereditary characteristic.—*E. T. Leddy.*

Lehner, J. Die Herstellung eines einfachen lichtelektrischen Mikrophotometers. (A simple photo-electric microphotometer.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Aug., 1934, *50*, 170–174.

Lehner describes and illustrates the construction of an easily assembled microphotometer and gives some applications of the device to clinical practice.—*E. T. Leddy.*

Kogel, G. Über die absolute chemische Bedingtheit organischer Substanzen für Röntgenstrahlenempfindlichkeit. (The absolute chemical limitation of organic substances for testing roentgen sensitivity.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Oct., 1934, *50*, 381–383.

In using 1.4 and 1.5 sodium naphtholsulfonic acid and 1.4, 1.5 and 2.5 sodium naphthylamine sulfonic acid and 1.2 and 2.1 quinondiazid that the photochemical decomposition of these organic compounds by roentgenray depends on the number, kind, combination, and location of the elements of the molecule. This fact establishes a definite starting point in researches on the analytic, synthetic, photomedical and photobiochemical relationships occurring in the irradiation of organic compounds.—*E. T. Leddy.*

Dotti, E. Erforschung der Funktion der Lymphgefässe und Lymphdrüsen mittels Röntgendarstellung nach subkutaner Injektion von Thoriumdioxyd (Tierexperimente). (The function of the lymphatics and lymph nodes as shown roentgenologically by the subcutaneous injection of thorium dioxide. An experimental study.) *Forschr. a. d. Geb.d.Röntgenstrahlen*, Dec., 1934, *50*, 615-618.

The author reports that when inflammatory conditions are present the shadows of the lymphatics and lymph nodes are less regularly, less intensively and less rapidly demonstrated than under normal conditions.—*E. T. Leddy.*

Tamiya, C., and Nosaki, S. Röntgenologisch-experimentelle Studien über die Bedeutung der "Polisographie" bei pathologischen Vorgängen am Magen, mit besonderer Rucksicht auf die Frühdiagnose des Magenkarzinoms. (Some roentgenologic and experimental studies of the value of the polysograph in pathologic processes in the stomach, with special reference to the early diagnosis of gastric carcinoma.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Sept., 1934, *50*, 264–280.

The authors report some experimental studies of the importance of the polygraph (Bernstein) and the polysograph (Tamiya) in showing pathologic conditions in the stomach, and especially of the value of the latter in detecting early lesions. They injected small quantities of 8–10 per cent ether alcoholic solutions of celloidin into the stomach of cats and the changes so resulting were compared with the polysographic findings. They found out that if the lesions involve the mucosa and submucosa only or the whole stomach wall to the muscularis and extend over an area greater than 0.7 cm., then there is rigidity in that portion of the stomach (primary organic contour rigidity). If the rigidity is near the pylorus then an area 0.5 cm. can be recognized. If the lesions extend to the muscularis there is a secondary rigidity of the opposite curvature. This type of defect in the pars pylorica produces a snail-like deformity with narrowing of the gastric lumen. At the periphery (pyloric side) of these lesions there is exaggerated peristalsis. Perigastric adhesions to the large or small intestine cause corresponding changes of contour, but those between the stomach and duodenum cause loss of peristalsis but not rigidity of contour. The same thing occurs when an extragastric tumor causes mechanical pressure on the stomach.—*E. T. Leddy.*